THE UNIVERSITY OF ALBERTA

SCIENCE AND READING PROCESSES

by

© Marina Duncan/Braithwaite

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled SCIENCE AND READING PROCESSES submitted by Marina Duncan/Braithwaite in partial fulfilment of the requirements for the degree of MASTER OF EDUCATION in Elementary Education.

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Supervisor

.....

K.G. Jackson

Margaret McNay

Date August 19, 1986

To Keir and Jesse

May you both treasure
your greatest fortune
- the ability to think!

ABSTRACT

This is a study concerned with ascertaining whether a relationship exists between the scientific processes employed during a scientific inquiry and the reading processes involved in facilitating comprehension of the written language. Initially, general literature related to the Process Approach to teaching was briefly explored. Then a survey of the literature enabled the writer to describe and analyze in detail the scientific processes specified for instruction in the Alberta Education Elementary Science Curriculum Guide (1983), and the reading processes advocated by the process oriented reading theorists.

A synthesis of the canvassed literature in the said areas was prepared in order to compare and contrast the similarities and differences. It was found that in all cases there was at least some evidence of similarity between the processes in the two fields. Some processes appeared to possess a great deal of similarity while other processes were similar to a lesser degree.

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CHAPTER ONE

INTRODUCTION TO THE STUDY

Overview

As educators, we play a paramount role in the learning and socialization of the youth who will live in the 21st Century. Curriculum planning must be a continuous process, relating what occurs in life and reflecting both the interior and exterior parameters of the classroom experiences. With the advent of unprecedented economic, scientific and technological changes in our present social reality, it is difficult for instructors to predict what knowledge of import will be demanded in the future. The inherent philosophy of the process-oriented approach to education advocates that a greater emphasis be placed upon instruction of the information processes or thinking skills, which are believed to be the more permanent, fundamental tools that enable students to "learn how to learn" (Bruner, 1960). This school of thought does not require teachers to be "Fountainheads of Knowledge" (Combs, 1981) and discredits such a concept as being totally unrealistic in this era of "The Information Explosion" (p. 360).

Initially, Process-Oriented Education was limited with respect to the study of science. The elementary science curriculum (Alta Ed., 1980) emphasized the instruction of processes and the formation of sound conceptual structures in contrast to the traditional orientation that stressed the learning of scientific facts. The program advocated that children be subjected to rather sophisticated concepts through first

hand, concrete, problem-solving experiences. It is believed that these concepts are more easily understood because the children are encouraged to observe, manipulate, investigate and test physical objects; whereas with many traditional textbook oriented elementary science programs students have been instructed to memorize and recall literal facts. The Manitoba Science Curriculum Guide (1979, p. 13) states "that processes are intellectual skills which are developed and used in both science and other areas of study." In conjunction with this view point Hayweiser (1966) stated that, "although the study of science is undoubtedly an intellectual endeavor science does not have the exclusive use of intellectuality" (in Science Council of the ATA 1981, p.2). The Alberta Teacher's Association explain, that ..."to the extent that the processes of scientific inquiry are intellectual processes, they are also encountered in other subjects taught in schools (such as mathematics, language arts, social studies etc). It is the systematic use of the processes with reference to the content area known as science which makes them scientific processes" (p. 3).

Within the area of reading instruction, discourse processing theorists (Fagan, 1981; Malicky, 1981; Cronin, 1982) advocate that the intellectual skills or... " processes employed in cognition in general are highly similar or identical to the processes of reading..." (Cronin, 1982, p. 58). Holding much the same philosophy espoused by the science curriculum Marturano (1968) debating in favour of a process reading instructional methodology states that,

> As a child's concepts and vocabulary grow through active and deliberately planned encounters in the environment, he can approach the printed page with a conceptual readiness and confidence which makes reading for meaning possible. Observing, describing, explaining and other logical operations are the conceptual skills through which one reads. Deliberate work with the child's conceptual skill will develop his reading ability (p.1).

Malicky further supports the process approach in reading instruction by stating that "the process approach gives the child strategies for reading; it focuses on the child and the HOW of reading." She believes it is incumbent upon instructors to develop in the young reader ... "the desired thinking processes" (1980, p. 5).

A number of "desired thinking processes" that Malicky, and Morturano refer to in their arguments, such as observing, describing, explaining, classifying, predicting, hypothesizing and inferring, appear to be similar in name at least to the processes taught in science programs. From this literature questions arise as to the possibility that some relationship may exist between the thought processes identified as being an integral aspect of scientific inquiry and the thought processes believed to facilitate reading comprehension.

Process education pursuant to the integrated philosophies propound that the basic thinking or problem solving strategies are flexible in nature and can be generalized to expedite all realms of knowledge acquisition. With respect to these prevailing beliefs, it would be of significant value for researchers to identify the fundamental thinking skills in each of the content areas in order to ascertain whether or not commonalities exist. Any relationships that may be identified should further the educator's understanding of how to more effectively integrate the content areas across the curriculum.

Statement of the Problem

This study is concerned with the possibility that there is a relationship between some of the scientific processes employed during a scientific inquiry and the reading processes involved in facilitating comprehension of the written language.

The scientific processes identified within the Alberta Education Science Curriculum (1983) are as follows:

1. observing,
2. classifying/serial ordering,
3. measuring,
4. communicating,
5. inferring,
6. predicting,
7. controlling variables,
8. interpreting data,
9. defining operationally,
10. hypothesizing,
11. formulating models, and
12. designing experiments.

The information processes advocated by Fagan (1981) and Malicky (1981) to be involved in bringing meaning to the printed message are as follows:

1. attending,
2. analysing,
3. associating,
4. generalizing,
5. classifying/sequencing,
6. synthesizing,
7. predicting/hypothesis testing, and
8. inferring.

With respect to the aforementioned processes this study will examine the following questions.

1. What is the nature of the processes in science?
2. What is the nature of the processes in reading?
3. What is the relationship between the processes in science and the processes in reading?

Definitions

1. Process

"Process... refers to all the random or ordered operations which can be associated with knowledge and with human activities", (Parker & Rubin, 1966. p. 2). Existing in an infinite variety of shapes and forms there are processes which create knowledge, communicate knowledge, utilize and apply knowledge. Whether it be cognitive, affective or corpritive, processes... "must have a construct - an underlying scheme which provides order and direction". (Parker & Rubin, 1966, p. 2).

2. Process Education

Formal intervention toward the facilitation and development of skills essential to dealing effectively with information and experience for the purpose of meaning making and obtaining goals (Cole, 1972, p. 52). Eastern Regional Institute for Education (ERIE) has defined process education as the systematic activity of the educational enterprise toward the cultivation of those generalizable and adaptive

behaviors which underlie all creative activity and which the learner engages in to acquire, organize and utilize information and experiences for effective problem-solving and productive learning (Seferin & Cole, 1975, p. 1).

3. Science Process Skills - are inclusive of ..."The usual range of science processes, such as observing and measuring, seeing and seeking solutions to problems, interpreting data, generalizing, and building, testing, and revising theoretical models" (Welch, 1981 in Discussion of Science Process Skills in Alberta Schools, Alberta Teacher's Association, 1981)

4. Reading Processes Numerous theorists ..."depict reading as a constant trade off of information between reader and text, and conceptualize this exchange as a set of cognitive processes which occur during and after reading" (Cronin, 1982, p. 54)

Procedural Outline

The examination of the relationship between the science and reading processes will be studied by surveying the literature relevant to the

Process Orientation, in order to ascertain whether or not there is a relationship between the information processes employed during a scientific inquiry and the thought processes involved in facilitating comprehension of the written language. Specifically the study will:

1. describe and analyze in detail the classification of processes specified for instruction in the Alberta Education Elementary Science Curriculum Guide (1983),
2. describe and analyze in detail the classification of processes advocated to facilitate language comprehension espoused by the process oriented reading theorists,
3. prepare a synthesis of the canvassed literature in the aforementioned areas in order to compare and contrast the similarities and differences that exist between the processes in the science and reading areas.
4. will attempt to derive implications from this research which may enable the writer to delineate and define the processes that have common functional foundations which are employed in both reading and science instruction,
5. will attempt to derive implications from this research which may provide information that will aid in the development of future research questions and instructional formats pursuant to the process philosophies.

Plan of the Study

The remainder of this study will consist of four chapters. Chapter two will focus on a detailed description of the Scientific Processes

specified for instruction in the 1983 Alberta Education Elementary Science Curriculum Guide. Chapter Three will deal with a detailed description of the processes advocated by Fagan (1981) to facilitate reading comprehension. In the fourth chapter the aforementioned processes from the scientific and reading content areas will be compared and contrasted in order to ascertain what similarities and differences may exist. The conclusion, summary and educational implications stemming from the study will be discussed in chapter five.

CHAPTER TWO

SCIENTIFIC PROCESSES

Introduction

> Science is an activity that takes place in the minds of [individuals]; it is the result of certain intellectual processes that make discovery possible. (Hurd & Gallagher, 1969 in Elements, 1982).

Today's science curricula emphasize the student's understanding and application of certain science "processes" involved in scientific inquiry. This "process approach" to science education directly stems from the pre-established 'scientific method'. Both the process approach and the traditional approach to science instruction are concerned with the identification of a problem, the canvassing of relevant background knowledge, the formulating and testing of hypotheses and an explanation or conclusion related to the experimental data. Nay et al (1971) state that, "...There are general processes involved in scientific methodology, all of which are used at one time or another by scientists regardless of their field of research...However, in the work of any given scientist each of these processes is applied only when required and in a manner dictated by the problem being researched in the discipline." (1971, p. 200). Inherent within the process approach lies the basic premise that the ..." complex behavior of scientists can be analyzed into simpler activities, and that these can be analyzed in a hierarchy of complexity for purposes of instruction" (Nay, 1971, p. 199). Pursuant to Piaget's theory of intellectual development, Alberta Education, within their 1983 Curriculum Guide, advocate that "By

offering a diversity of interesting and challenging experiences, the science program will involve children directly in personal rather than vicarious learning. It is through direct learning activities that children develop proficiency with the process skills of science and improve their abilities to think critically. By placing emphasis on these skills, the science program will help the child to evaluate and assimilate information rather than just accumulate it. Thus, the program should emphasize ways of gaining and processing information rather than learning information itself" (P. 1). The formulation of the 1983 Alberta Elementary Science Curriculum is based predominantly upon two process oriented science programs: Science - A Process Approach, (SAPA), and The Process Approach to Teaching Science by Nay et al.

I. Science - A Process Approach

Science - A Process Approach (SAPA) is a psychologically based program which relys heavily upon the learning theory of Gagne. It was developed in the mid 1960's under the auspices of the American Association for the Advancement of Science. It was the first science program which explicitly enumerated a list of science processes. The major emphasis within the program was upon the processes of science in an inquiry form. These processes which were arbitrarily classified by a group of scientists and educators are as follows:

1. Observing: Identifying objects and object properties, changes in physical systems, controlled observations, ordering of a series of observations.

2. Classifying: Classifications of physical and biological systems, multi-stage classifications, coding, tabulation.
3. Using Numbers: Identifying sets and their members, ordering, counting, adding, multiplying, dividing, finding averages, using decimals, and powers of ten.
4. Measuring: Identification and ordering of lengths, demonstration of rules for measurement of length, area, volume, weight, temperature, force and speed.
5. Using Space/Time Relationships: Identification of shapes, movement and direction, rules for straight and curved paths, changes in position, and finding of linear and angular speeds.
6. Communicating: Bar graph descriptions of simple events, describing physical objects and systems, construction of graphs and diagrams for observed results of tests.
7. Predicting: Interpolation and extrapolation in graphic data, formulation of ways of testing predictions.
8. Inferring: Inferencing for observations of physical and biological phenomena, construction of situations to test inferences drawn from hypotheses.
9. Defining Operationally: Distinguishing between operational and nonoperational definitions, constructing operational definitions in new problems.
10. Formulating Hypotheses: Distinguishing hypotheses from inferences, observations, and predictions, constructing and testing hypotheses.

11. Interpreting Data: Describing graphic data and inferences based upon them, constructing equations to represent data, relating data to hypotheses, generalizing from experimental findings.
12. Controlling Variables: Identifying manipulated and responding (independent and dependent) variables in a description or demonstration of an experiment, conducting an experiment, identifying the variables and describing how variables are controlled.
13. Experimenting: Reiterating the sequence for controlling variables, interpreting accounts of scientific experiments, stating problems, constructing hypotheses, and carrying out experimental procedures.

(Seferin, 1975, p. 42)[8]

Gagne proposed that children should take part in the critical and the logical mode of thinking inherent in each of these scientific processes. He considered that these scientific processes should become the organizing emphasis for science instruction.

II. The Process Approach to Science Teaching

The second process oriented science program from which the Alberta Science Curriculum takes much of its method and philosophy is "The Process Approach to Science Teaching" by M.A. Nay et al. (1976). Because many of the science educators were generally dissatisfied with programs such as SAPA, that were predominantly process based with little or no emphasis on the content of science the Edmonton Junior High School Science Project, under the auspices of M.A. Nay of the University of Alberta, developed a new methodology for teaching for the scientific processes.

Cognizant of the importance of both the process skills and scientific content, Nay and associates attempted to develop a theoretical construct from which a science curriculum could be formulated. In Nay's words, "To enhance a student's comprehension of how scientists work and scientific knowledge evolves, a science curriculum must be provided in which selected concepts and the associated processes of inquiry are integrated" (p. 197, 1971). Within Nay's process approach to science teaching, An Inventory of Processes in Scientific Inquiry was developed. Dealing with only the cognitive domain, Nay began developing the inventory by gathering as detailed an account as possible of how different scientist carry out their investigations. A comprehensive list was compiled which included those processes which were considered to be generally common to all scientists in the various scientific domains. The processes were delineated and defined in a formal sequence in order that their interrelationships with one another could be clearly depicted. No rigid sequential pattern is implied, as two or more processes may overlap during a single operation. Some problems confronted may require the use of all of the processes whereas in other cases only a few may be required. Nay et al.'s Inventory of Processes in Scientific Inquiry is cited in appendix A.

Description of the Scientific Processes

Within this section there will be a delineation and description in detail, of twelve processes, which were selected by Alberta Education in order to form a major component of the Elementary Science Curriculum.

1. observing,
2. measuring,
3. classifying,
4. communicating,
5. inferring,
6. predicting,
7. controlling variables,
8. interpreting data,
9. defining operationally,
10. hypothesizing,
11. formulating models, and
12. designing experiments.

(Elementary Science Curriculum Guide, Alberta Education, 1980, 1983)

1. Observing

> "The process of science has no discernible rules. It is a creative human enterprise which no two scientists perform in precisely the same way. Its practice demands utmost honesty, freedom from prejudice, and a willingness to conform to observed facts"
> National Science Teaching Association, (NSTA) 1964

It is the opinion of Funk, Okey, Fiel, Jaus and Sprague that "the ability to observe is the most basic skill in science and essential to the development of other science skills such as inferring, communicating, predicting, measuring and classifying" (1979, p. 3). This initial step within the science processes leads an individual to pose questions and find appropriate directions for further investigation. According to Kuslan and Stone (1972) observation is regarded not only as a preliminary step in the utilization of the scientific processes but also as a preliminary step taken before one can comprehend important scientific facts and principles.

Observation is the utilization of any or all of the five senses in order to gain information about the surrounding environment. Almost all

individuals are born with the ability to observe as they explore their world. Utilizing an individual's five senses enables the generation of such property information as the object's colour and or its change in colour and state over time, shape, size, texture, taste, odor, sound and so on. Observation is raised to a more advanced intellectual level as an individual becomes capable of more and more precisely describing the detailed properties of objects, events and situations. Galbraith suggests that "in some ways younger children may be better observers than we as adults, as they generally are more ready to accept a wide range of sensory input as worthy of their attention" (1983, p. 19).

The act of observing may not be as objective as scientists perhaps once believed. Current literature questions the subjectivity that is involved when we interpret an observed object through our own histories. In reference to this philosophy, Jacknicke (1985) ascribes to the opinion that as we observe an object the act of observing changes the object.

2. Measuring

According to the Science Council of Alberta Teacher's Association (1981), "Measuring is a process of ascertaining the dimensions or quantity of an object or event" (p. 17). Kusland and Stone (1972) define measurement as "the comparison of one physical aspect of an object or event with a standard unit" (p. 56). Scientists need to have a working knowledge of how to accurately and precisely use a variety of measurement tools in addition to selecting the most appropriately calibrated measuring device for a particular study.

The process of measurement is an essential skill in the disciplines of both science and mathematics. Science as a discipline itself could not have developed to its present level without mathematics. According to the National Science Teaching Association (1964), "mathematics is the language by which one describes the order in nature and which in turn, leads to a clearer understanding of that order" (NSTA, 1964, p. 31). Thus the mathematical treatment enables the scientist to refine a 'level of confidence' in his observed data. The National Science Teaching Association crystalizes this train of thought by stating that quantitative information facilitates the formulation and establishment of laws. The more precise the data the more rigorously and systematically a scientist can check the assumed relations of dependence.

3. Classifying

Piaget spent a great deal of his life in pursuit of the discovery of a more reliable means of identifying, within a particular stage of cognitive development, the individual's abflity to formulate various scientific and intellectual concepts. Central to his philosophical theory of knowledge Piaget advocated that in order to make sense out of the world we must classify into groups the overwhelming number of objects, symbols, and ideas with which we come into contact.

The process of classification is an essential mental operation which enables the human mind to diminish the vast amounts of information it is required to accumulate and utilize. Whyte (1969) embellishes this by stating that, "as humans we belong to that component of nature given

to organizing and structuring. We not only physically organize ourselves and our environment...we also organize our perceptions of the physical world into abstract structures" (in Rawson, 1979, p. 205). Britton (1970) crystalizes this thesis by stating that, "the point to underline, however, is the degree to which we rely upon the process of classification. Experience is kaleidoscopic: the experience of every moment is unique and unrepeatable. Until we can group the items in it on the basis of their similarity we can set up no expectations, make no predictions: lacking these we can make nothing of the present moment. Without categories of experience, therefore we should remain imprisoned in the uniqueness of the here and now. What Piaget has called "the manifold and irreducible present' is in fact conquered by what Sapir describes as 'the reduction of experience to familiar form.'" (p. 27). Classifications of the environment involve the identification, abstraction, analysis and utilization of explicit parameters in terms of which groupings are made. Rosch (1976) suggests that individuals automatically abstract similarities, thus objects in a group which are analogous are usually noted while dissimilar objects are frequently ignored. Using the term, "categorizing" synonymously with that of "classifying", Bruner concurs with Rosch by purporting that,

> To categorize is to render discriminately different things equivalent, to group objects and events and people around us into classes, and to respond to them in terms of their uniqueness (1956, p.1).

The SAPA program in addition to numerous other process oriented elementary science curriculums highly emphasizes Piaget's work in

classification within their units of study. Specifically within SAPA there are several 'hands on' exploratory exercises which attempt to increase, in a hierarchical fashion, the students' skills of classification. Understanding of classificatory skills facilitates the students' ability to conceptualize greater amounts of scientific information or content.

Jacknicke (1982) contested that students should not only be required to classify objects according to the properties suggested by the instructor but that they be provided with the scope to incorporate their own criteria. The properties utilized for the basis of the classification should be described and justified by the student. This is essential in the understanding that all classification schemes are arbitrarily established in order to suit the needs of the individual or the society at large. In agreement with this statement Manitoba Education hold that, "classification systems are arbitrary and their usefulness depends upon the function they serve. For example, a series of animals could be classified as follows:

Vertebrates - lion, mouse, giraffe

Invertebrates - grasshopper, amoeba, earthworm

1 syllable - mouse,

2 syllables - lion, giraffe, earthworm, and

3 syllables - grasshopper, amoeba

(1979, p. 14,)

Classificatory schemes (such as the one cited above) can be expressed as a chart, diagram or in any other communicable form. When

schemes are represented diagrammatically the bonds between the subordinate and superordinate hierarchically related categories become readily apparent. Within the study of biology an example of a hierarchical classification is:

Living Things

Vertebrates — Invertebrates

Mammals — nonmammals — arthropods — Other

reptiles — fish — birds — Insects — Crustaceans

amphibians — Arachnids

Scientists employ the essential data processing strategy of classification in order that the incoming data, within an investigation, can be interpreted or conceptualized. Classifying, rearranging, comparing and ordering makes the data more meaningful according to Nay et al. (1971). By categorizing data into a more organized form interpretations and generalizations made concerning the informational data may be revealed more readily.

4. Communicating

"Only dialogue, which requires critical thinking, is also capable of generating critical thinking. Without dialogue there is no communication, and without communication there can be no true education."

(Paulo Friere (1981, p. 81)

The process of communication is fundamental in all human activity. Funk et al. (1979) consider that "our ability to communicate with others is basic to everything we do. Graphs, charts, maps, symbols, diagrams, mathematical equations, and visual demonstrations, as well as the written or spoken word, are all methods of communication used frequently in science" (p. 23). They continue to assert that within all problem solving situations related to science or otherwise, effective communication which is clear, precise and comprehendable, is essential.

Kuslan and Stone (1972) discuss the scientist's commitment to appropriately communicate his findings or conclusions to others. Referring to science as a public pursuit, Kuslan & Stone state that scientist's descriptions must be clear and accurate in order that they may be tested by other scientists. Recognition should be made of... "the assumptions and inferences that shape their communication" (Kuslan & Stone, 1972, p. 57). It is imperative that scientists record the observed data or phenomena in a brief but realistic and descriptive manner. A specific type of vocabulary is often developed by a scientist in order to aid him to more succinctly describe both qualitatively and quantitatively the object's properties or the differences of its properties over time. Thus as observations become more complex there is a greater need for a more astute and sophisticated vocabulary.

Studies conducted by Allen (1971) comparing children in the first grade process oriented SCIS program with children in a traditional first grade science program indicated the children in the latter program were better able to describe observed objects by sorting and grouping their

properties and could generalize these specific property words to other situations. Robinson (1965) proposed that "...an individual who is developing scientific literacy will increasingly ...understand the role of man as an interpretor of nature and that as a consequence, the study of language is as essential to the scientist as the study of observation" (in Romey, 1968, p. 153).

Scientists are continually having to deal with the task of trying to understand new and complex concepts. Stating that there is an interdependence between language and concept development, the National Science Teaching Association Curriculum Committee (1964) emphasize that, "it is difficulty to form a concept without a language rich enough to express it" (P. 10). Ideas that are well articulated in either a verbal or written form facilitate the scientist's understanding and application of the concepts under study.

Within the discussion paper on the teaching of Science Process Skills In Alberta Schools, the Science Council (1981) has advocated that communication be omitted from the existing list of scientific processes within the Alberta Science Curriculum Guide. Defined by Mott (1981) the process of communication is regarded as involving both the interactions of transmitting and receiving information. Listening, reading, viewing and sensing (tasting, touching, smelling) are the communication skills used in order to receive incoming information. Speaking, writing and the nonverbal presentation of information are regarded as the transmitive form of communication. Relating the communication skills with the cognitive processes or critical thinking skills, Mott..."

defines critical thinking as a set of intellectual skills necessary for "processing" information which has been "received" and which may be "sent". Thus there appears to be a constant interplay of communication skills and critical thinking skills" (p. 13).

With regard to the list of processes of scientific inquiry, the scientist receives information predominately through observation (the utilization of the five senses) and measurement which is often seen as an extension of observation. Upon receiving the information the scientist, when dealing in the cognitive domain, commences to ..."process the information (critical thinking) in all other scientific process skills" (Mott, 1981, p. 14). According to the Science Council, "that part of "communicating" called "sending" information can apply to all processes of scientific inquiry e.g., as the student describes observations, enunciates a problem or hypothesis, depicts data in graphical or symbolic form, formulates generalizations etc." (p. 13,14). Therefore in essence communication is viewed as an "over-arching" process required in the performance of all processes of scientific inquiry and thus accordingly is not regarded in isolation as an individual process.

5. Inferring

According to Nay et al. (1968) the process of inferring falls within the category of Data Interpretation. They consider that "interpretation involves inferences since often the mind must go "beyond the facts" for an appropriate generalization or explanation" (p. 7,). Evolving from both direct and indirect observations, inferences are

tentative in nature, thus continually being modified on the basis of newly cited evidence (Alberta Science Council 1981).

All interpretations, of which inferring is inclusive, are considered to have some use when they are made in light of supporting evidence. Interpretations do not constitute a final answer but act, in a sense, as ..."a check for the learner to determine if he is on the right track" (Perth Board of Education, 1979). One should not make the assumption that there is only one right track a scientist must follow throughout an investigation, for there are many roads a scientist may correctly decide to travel. With conscious reasoning several inferences can be made from a single or a set of observations. Of great import within the scientific domain is the recognition of the distinction between the actual observation and the inferences made concerning the observations.

Galbraith (1983) discusses how the inexperienced individual will more often, in an inaccurate manner make categorical judgements in light of very little evidence. With more experience the learner would gather more information before making any inferences. Nay et al. maintain that ..."vigilance must be exercised in interpreting data; that is, no more should be inferred than is justified. There is always a limit on the new knowledge that can be obtained in any single investigation" (1978, p.7). Plester (1972) suggests that inferring denotes "...the ability to draw conclusions concerning the nature of, or underlying causes for, a phenomenon or event based upon observation of the phenomenon or event and upon reflection regarding the observation" (p. 4). Bruner (1957)

advocated that an inference goes beyond the information that is given. He discusses three forms of inferring. The first form ..."consists of learning the defining properties of a class of functionally equivalent objects and using the presence of these defining properties as a basis of inferring that a new object encountered is or is not an example of the class (p. 42). Bruner also considers that the second type of inferring occurs when "one learns the probability texture of the environment, one can go beyond the given by predicting its likely concomitants" (pp. 43). A third form of inferring according to Bruner is illustrated in terms of the transitive property: A=B, B=C, A=C.

6. Predicting

Predictability is considered by Kuslan and Stone (1972) as being one of the most important characteristics of science. Forecasting what a future observation will be is a prediction according to Funk et al. (1979). A prediction which is not based on observation is a guess states Alberta Education (1983).

Funk et al. consider that when accurate predictions about objects and situations are formulated scientists can better determine a more suitable behavior towards our environment. By putting some kind of order on our environment it permits scientists to discover or to create particular patterns. Once these patterns become recognizable, scientists learn to expect their reoccurrence under the same conditions. Nay et al. concur by maintaining that "predictions are based on the fact that the universe operates in a regular manner, and that scientists come to expect that phenomena will alwyas occur in the same manner.

Predictions often require precise measurement. Predictions often involve, within the range of observed events, the interpolating or extrapolating of simple or complex graphic data.

Some researchers state that it is important that scientists not only make predictions but also test for their accuracy. When predictions are tested and found to be incorrect the immediate feedback should lead scientists to re-examine the basis for their prediction. The prediction may be altered and a re-examination conducted which takes into account the identifying and controlling of variables that may have affected the results (Altberta Education, 1983). Thus the accuracy of the scientist's predictions in turn facilitate the validity of his investigation. Nay states however, that it is the hypotheses that is always tested rather than the more informal prediction.

Funk et al. discuss the difference between an inference and a prediction by suggesting that an inference is an explanation or an interpretation of a single or a set of observations, whereas a "prediction is based on careful observation of the inferences made about the relationship between observed events" (p. 53). Therefore based on the scientist's inferences predictions about future observations are made.

Galbraith (1983) suggests that the process of predicting is dependent upon the process of hypothesizing. Stating that within an hypothesis one recognizes a relationship, Galbraith claims that..."on the basis of formal logic it would seem necessary for us to hypothesize before we could predict, for it is only logical that we should recognize

a relationship before we can apply that relationship to a prediction" (p. 18).

The six scientific processes dealt with, thus far have been defined as "basic" processes (SAPA 1968, Alta Ed 1983, Science Council of ATA 1981, Galbraith 1983). The following processes are referred to as "integrated" processes which overlap with one another and are considered to embody the "basic" process skills.

7. Controlling Variables

According to Nay et al. (1968) variables are defined as ..."factors, conditions or properties which operate within or influence the phenomenon under investigation" (p. 1). All of the variables which influence an investigation must be either tested or controlled. Thus it is normal to examine only one of the variables while holding all of the others constant.

Within an experiment the isolated variable which is deliberately altered in a systematic way is referred to as the manipulated or independent variable. The variable which may change as a result of the independent variable is referred to as the responding or dependent variable. The variables which are held constant throughout the investigation and are kept from affecting the outcome are referred to as being controlled. A scientist controls variables for the purpose of knowing for sure that only the manipulated variable affected the responding variable. The manipulated variable has an unspecified function on the responding variable therefore basically there is a relationship between them.

8. Interpreting Data

Falling within the category of data conceptualization (Nay et al. 1970) interpretation is defined by the Science Council of the ATA (1981) as ..."the process by which sense is made out of the observations in the form of inferences, generalizations or explanations" (p. 26). Jacknicke (1985) considers however that the scientists' past history should be considered when discussing interpretation. Due to individual experiences each scientist may have a different consideration of what appropriate data supports the inferences, generalization or explanations.

According to Keeton (1973) it is not enough for a scientist to merely amass data, it must be organized and be put into some type of pattern or trend so that it can be ..."fitted into some sort of generalization" (p. 2). ...otherwise the data remains essentially isolated and useless. When observed data is depicted within a graph or equation (SAPA 1968) patterns or trends may emerge which make the formulation of the generalization or explanation more facile.

It is of great import that there is a distinction made between the facts observed and the interpretations made concerning those facts. In addition, Altberta Education (1983), states that distinctions should be made between relevant and irrelevant or extraneous observations in order that only the most important data be dealt with. Interpreted data may lead to the construction of new and more accurate inferences, hypothesis and predictions. (Manitoba Education 1979, Nay et al. 1970, Alberta Education 1983).

9. Defining Operationally

The process of defining operationally is regarded by Nay et al (1968) as an indirect process since ..."it is primarily an aspect of the language of science. Scientists find it useful and convenient to use a word or brief phrase to identify the operation of an object or an event in nature" (p. 7). The process of defining operationally requires that a scientist provides a definition that minimally describes the way in which an object or situation can be observed and tested. Alberta Education (1983) similarly state that "an operational definition is simply a statement that tells us, "what is done" and "what is observed" when describing an object or event" (p. 90). From the point of view of Funk et al. (1979) "an operational definition is a definition that describes how to measure a variable" (p. 172). Thus in other words, "to operationally define a variable means to decide how you will measure it..."(p. 192). They advocate that an operational definition should be clear and concise enough that other interested researchers should be capable of independently carrying out the measurement.

There can easily be more than one operational definition for an object or concept being investigated. The suitability of a definition depends upon the scientist's intention in an investigation. Funk et al. (1979) provide an example of three possible ways one may operationally define 'size of automobile'.

a. amount of weight it is able to pull

b. the distance from the front bumper to the rear bumper

c. the horsepower of the engine (p. 174).

10. Formulating Hypotheses

According to Nay et al (1968) "a hypothesis is a possible or tentative explanation for a phenomenon. This may be anything from a conjecture, guess or assumption to an explanation which is highly probable in the light of known observations or facts" (p. 3). Nay considers that an hypothesis must be stated in a manner that can be proven or disproven, thus in essence it acts like a 'selecting device', directing the design of the investigation in addition to facilitating the selection of further observations.

Funk et al (1979) consider that, "hypotheses are guesses about the relationships between variables" (p. 155). During hypothesis construction the scientist identifies or predicts which of the manipulated variables could possibly effect the responding or dependent variables within the problem. They clarify this viewpoint by stating that "if the manner in which a variable can be manipulated and the type of response expected is clearly stated in the hypothesis, then much of the work in planning how to collect the data has been done" (Funk et al., 1979, p. 175). The American Association for the Advancement of Science (AAAS) (1965) consider that an hypothesis is defined ..."as a generalization that includes all objects or events of the same class. Hypotheses can be formulated on the basis of observations or inferences" (p. 29). In a slightly different vein Keeton (1973) considers that scientists utilize their generalizations in order to construct hypotheses concerning data that has not yet been observed. If the hypothesis appears to be valid the scientist can feel more confident

about their generalization. In an open ended continuum new hypotheses are generated to further test the generalizations.

Disagreeing with the American Association for the Advancement of Science (AAAS) and Keeton, Pearson (1975) propounds that ..."an hypothesis does not necessarily have to constitute a generalization. It may in fact consist of an attempt to account for a very specific situation in very specific terms" (p. 5). Kuslan and Stone (1972) question the difference between an hypothesis and a theory. While Rogers (1960) advocates that hypotheses are the building blocks required for theory formation, Suchman (1966) suggests that both hypothesis and theory are terms which are synonymous with one another. Also espousing that hypothesis and theory building are closely related, Kuslan & Stone claim that an "hypothesis is defined as a tentative idea about certain relationships which connect observable events".../ whereas ..."a theory may be described as a fairly well confirmed hypothesis, although many hypotheses are not sufficiently interpretative or explanatory to be accepted as theories" (1972, p. 32). Considering that the more hypotheses formulated the more the chance that the solution to the investigation will be found, Pearson (1975) in conjunction with Osborn (1957) claim that "quantity produces quality". Pearson considers that high quality hypotheses should possess these particular qualities:

1. The hypothesis accounts for all of the presently known relevant facts.
2. The hypothesis is fruitful in directing further action enabling the prediction of specified future observation.

3. The hypothesis can be tested or verified either immediately or eventually.
4. The hypothesis is precisely stated.
5. The hypothesis is stated in the simplest form adequate for the expression of all facets of the problem

(Pearson 1975 p. 22,23).

11. Formulating Models

The Science Council of Alberta Teacher's Association (1983) define this process as the utilization of physical or mental models so as to describe ..."the behavior of something that is unfamiliar in terms of something whose behavior is familiar" (p. 28). Regarded as more or less an exact copy of some physical structures, scientific models enable one to think in concrete terms and to understand the logical reasoning for the phenomenon which is encountered. An example of a scientific model is the picture of the atom which was made to resemble a miniature solar system, created by Neils Bohr in 1913.

Generally simpler than the real structure, models help to organize the scientist's thoughts and to supply possible explanations of how specific systems function. Scientific models may also be described in terms of words, mathematical formulae, diagrams, analogy and physical or three dimensional reproductions.

An important characteristic of scientific model making is that it invariably draws a number of predictions which can be tested. New discoveries of a system are examined and frequently the existing or faulty model is changed or revised to accommodate new data. In a

similar vein, The Science Council of the Alberta Teacher's Association (1983) maintain that "constant vigilance is necessary to ascertain the validity (fit) of the model or analogy with the phenomenon modelled. Models often have to be revised in order to accommodate both old and new facts"(p. 23).

Scientists must be very cautious not to exclude other ways of looking at their data when they already possess a model which represents their present theory or idea. Sometimes scientists may also fall into the trap of trying to make the model fit the data.

12. Experimenting

"There are laboratories wherever there are problems to probe and insights to be gained" (Parker & Rubin, 1966, p.32).

The process of experimenting may be viewed as the meshing together or amalgamation of all of the scientific processes discussed thus far. Alberta Education (1983) considers that experimenting is the synthesis of all of the available knowledge so as to test the validity of the hypothesis(es). They maintain that essentially experimenting may be regarded as simply an answer to the question, "Is my hypothesis valid in this situation" (p. 64). Kuslan and Stone (1972) suggest that..."an experiment is a rather precise way of asking questions of nature" (p. 10). Considering that the designing of an experiment is in itself a complex intellectual process the Science Council of the Alberta Teacher's Association (1983) state that experimenting requires the planning of an investigation in order to obtain a solution to a problem or to ascertain unknown effects of laws.

Minimally an experiment can be viewed as: "test or observe; manipulate one variable systematically, leaving all else (including a "control") as unchanged as possible; test or observe again" (Cowen 1978 p. 65). Thus within an experimental situation the scientist is required to identify and control the variables or factors which are capable of effecting the results.

In experimentation, says Wilson (1952), "the scientist generally finds it necessary to rely on controls, which he defines as "similar test specimens ...subjected to as nearly as possible the same treatment as the objects of the experiment, except for the change in the variable under study" (p. 40). If test specimens are poorly chosen, conclusions must be limited to only those specimens. Overgeneralizations are therefore frequently related to the lack of controls and improper sampling procedures.

Most science textbooks will initially discuss a prescribed design or plan of how an experiment should be carried out. The National Society for the Study of Education in the 59th yearbook (1969) advocated that there are numerous methods for solving scientific problems. They propound that there is not just one correct "scientific method" but rather, there are probably ..."almost as many methods as there are scientists and problems to be solved...what is done is highly flexible and quite personal...The methods of science are something more than measurement, laboratory techniques, and data processing followed by logical deductions. Sometimes they are not very logical, but the search for truth is always present" (p. 35). Kuslan and Stone consider that

within science instruction the laboratory experience is a procedure which most often verify's already known information. They consider that the manipulation of scientific apparatus should not necessarily be labelled as an experiment for the term experiment should be reserved for a more creative endeavor. Within a genuine experiment, Kuslan and Stone contend that a true question or problem exists and the experimentor endeavors to ascertain or examine conceivable relationships, causes and effects.

Nay et al. espouse the philosophy that science is an open-ended and continually unfinished business. In agreement with Nay, Zukav states

> "I don't think that [science] will ever have an end. I think the novelty of nature is such that its variety will be infinite - not just in changing forms but in the profundity of insight and the newness of 'ideas'.
>
> (1979, p. 314)

Chapter Summary

It has been the intention in this chapter to discuss in detail the twelve scientific processes advocated by the 1983 Alberta Science Curriculum Guide. Definitions and explanations of each of these processes were cited by various science researchers and educators.

CHAPTER THREE

READING PROCESSES

Introduction

Reading Comprehension is rather an abstruse concept which has been observed and defined with great difficulty. Fagan (1981) proffers that ..."comprehension is the most unwieldly aspect of reading to be taught or assessed" (p. 1).

Saddled with the obstacle of defining a focus within the parameters of reading comprehension instruction, Durkin (1976) proposed a definition as follows:

1. To teach the child the meaning of a unit that is larger than a word
2. To teach them how to work out the meaning of such units.

The word, "how" plays a key role in Durkin's definition as it denotes what is labelled as the process orientation of reading instruction. During the past decade there has been much controversy over the value of the process versus product approach to language comprehension instruction.

Malicky (1980) in favor of the process orientation clarifies the distinction between the two different approaches. With regards to the more commonly known "product" or "skills" methodology, Malicky stresses that the prevailing opinion is that knowledge of the hierarchically ordered skills is imperative for the student who is learning to read. If the prescribed sequence of reading skills have been learned the

student is then considered to possess enough information that will enable him to become a proficient reader. Malicky emphasizes that the skills approach focuses its philosophy upon the "what" of reading.

Malicky further elaborates by stating that, "In contrast, the focus of a process orientation to reading is on the "HOW" of reading, specifically on how the child is attempting to reconstruct meaning from print. No a priori decisions are made regarding "WHAT" the child needs to know to process print effectively" (1980, p.1).

Lindfors crystalizes this notion by making reference to the many common complaints that students are graduating from our school system, unable to perform on composition, vocabulary and reading comprehension exams. She believes this problem is directly related to the "heavy emphasis on lower-level cognitive processes (recalling, memorizing) rather than on higher-level cognitive processes (applying, analyzing, synthesizing, evaluation.)" (p. 260) Lindfors emphasizes however that poor performance on a reading comprehension exam cannot be blamed solely on the use of the lower cognitive processes, because children are capable of grasping the basic facts but they are often incapable of knowing "HOW" to use them.

Reading specialist, Russel Stauffer, concurs with this philosophy by proposing that "it is both comforting and encouraging to know that the intellectual potential of children can be nurtured not merely by imparting knowledge to them but by aiding them to master the cognitive-affective (thinking-feeling) skills that will permit them to be critical, creative, compassionate readers who perform with

confidence" (1972, p. 27). Fagan (1981) considers comprehension to be both a process and a product. To distinguish between the two, he refers to the interaction between the reader's prior knowledge and their use of the cognitive processes as comprehending and the product the reader obtains is referred to as comprehension. He clarifies this by stating that,

> As a product, comprehension occurs each step along the way in conjunction with the processes which contribute to it. Thus, readers may be interrupted during their reading to ascertain either the processes themselves or the resultant comprehension of the author's meaning at that point in time. It would thus appear that there might be a relationship between the various processes brought into play and the comprehension arising as a result of this interaction (1981, p. 1).

Accordingly, a reader, possessing the working knowledge of how to employ the cognitive strategies can more effectively process the meaning from the printed information. It is believed by process oriented researchers that when the cognitive strategies are appropriately activated there is a more vitalized interaction between the reader and the text. Such an interaction instills in the reader the understanding of how to integrate one's personal knowledge and language experiences with that of the author.

Interactive processing theorists believe that comprehension ..."involves both the processing of text and the use of experiences and expectancies the reader brings to the text (Harris & Hodges, 1981, p. 160). Thus readers bring to the story or printed message a wide range of experiences and background knowledge which influence their interpretations of the author's message. In conjunction with this view Maturano (1968) referred to reading as ..."an active process of

reconstructing meaning from one's total surroundings, not merely from the printed page. (p. 4). Interactive comprehension theorists, Goodman and Burk (197) state that, because of the obvious difference between the language, thoughts, and meanings of an author, and those of the reader, reading can never be an exact process. ...However, since readers are compelled to understand what they are reading, they interpret actively while reading in order to gain meaning, which is their ultimate goal. The reader is as active in searching for meaning as is the writer in creating written language" (p. 3).

It would appear from the above statements that comprehension is reached when the reader employs the appropriate cognitive processes in order to maintain a balance between his background and linguistic knowledge and the background and linguistic knowledge of the author. Thus the cognitive processes may be viewed as facilitating the interactive behavior between the reader and the text.

Description of the Reading Processes

This section will attempt to describe and analyze in detail the classification of processes, considered by the process oriented reading theorists, to be involved in reading comprehension.

Fagan (1982) has devised the Feature Analytic Model which depicts how the cognitive processes are the vehicles by which the input (print) and the output (reader's prior knowledge: language, self, tasks, emotions) interact. Fagan's model outlines how the author and the reader are dependent upon their interaction with the cognitive processes. Within the Feature Analytic Model Fagan makes reference to

eight information processes. No rigid sequential pattern is implied as two or more processes may be, and are, often overlapped during a single operation. The cognitive processes which will be examined are as follows:

1. attending,
2. analyzing,
3. associating,
4. generalizing,
5. classifying,
6. synthesizing,
7. predicting/hypothesis testing, and
8. inferring.

1. Attending

The process of attending is the most preliminary action a reader takes when entering the reading situation according to Fagan (1981). Cronin (1982) states that, "the process of attending determines the amount and type of external stimuli which reach the mind through the various sensory channels" (1982, p. 59). The majority of information a reader may receive from the communication situation may be attributed to the utilization of their auditory and visual senses. Marturano (1968) asserts that the foundational basis of reading depends not upon listening, but upon close observation. Cronin (1982) clarifies Marturano's opinion by stating that, A listener may attend simultaneously to the voices, gestures and posture of the speaker; whereby the reader is provided with only visual stimuli (p. 59).

Cronin believes that the process of attending is the primary stage the reader must go through in order to decode the graphic information. The amount of attention a reader must give to the graphic symbols is a matter of controversy within the area of reading research.

Theorists who hold a "bottom up" viewpoint of reading purport that in order for comprehension to take place, the reader must attend to each and every letter and word within the passage. "The model of reading as a successive series of feature extractions, presupposes attention to word features such as spelling pattern, thus demanding high reader "utilization of presented graphics" (Cronin 1982, p. 60). Theorists who hold a "top-down" view of reading consider that the reader's attending behavior is directed by his visual scanning system, his language, culture and experiential knowledge in addition to his purpose for reading the selection. Hochberg (1970) and Goodman (1975) advocate that "with the aid of scanning strategies, peripheral vision, and predictions, the eyes attend only to the appropriate visual cues" (Cronin 1982, p. 60).

Royer (1978) referring to the "top-down" theory as a strong form of comprehension, suggests that comprehension is a natural extension from the perceptual process. He elaborates upon this notion by espousing that the reader's world knowledge, stored in his semantic memory, provides a large and immediate contribution to the linguistic messages which are attended to. He maintains that upon instantaneous recognition of the words..."several messages can be operative in the system simultaneously (for example, when one message is being comprehended, another may be undergoing linguistic decoding" (p. 11).

Smith (1978) appears to go one step further than Royer by proposing that even before the printed word is attended to, comprehension is already taking place. He clarifies this notion by hypothesizing that

the reader's decision to attend to a word is dependent upon the number of alternatives he has to choose from. Accordingly when there are fewer alternatives, the number of features the reader must attend to is diminished. Smith suggests therefore that meaningfulness decreases the number of linguistic features the reader needs to attend to and discriminate.

Using his own terminology Smith suggests that if a reader is subjected to the decoding of every letter or word, his brain may become so "overloaded" with the graphic stimuli that comprehension fails to take place. He refers to this problem as "tunnel vision". Smith (1978) espouses the need for selective attending whereby the reader utilizing his higher level processes divides his attention between both grapho- phonics and comprehension.

Fagan (1981) and Cronin (1982) believing that neither a completely "top-down" or "bottom-up" approach is a valid solution concur with De Beaugrand's (1981) interactive model of reading. "The interactive view allows for flexibility in attention, and gives the reader autonomy over his scanning strategies, allowing him to use graphic information selectively according to purpose" (Cronin 1982, p. 61).

In summary the writer supports Cronin's viewpoint that attending is a process which determines both the amount and type of outside stimuli an individual receives through his various sensory channels (Cronin 1982). Fagan (1981) considers that attending is the first step a reader must take in order to decode the graphic information. Marturano (1968) and Cronin (1982) assert that a reader is only provided with and is thus

most dependent upon the incoming visual stimuli. Both "bottom-up" and "top-down" models of reading were discussed. Within the "bottom up" approach the reader comprehends the text by attending to each and every graphic detail. On the other hand within the "top-down" model of reading, comprehension is attained by the reader's attention to only the most appropriate visual cues. Fagan (1981) and Cronin (1982) both support De Beaugrand's (1981) interactive model of reading whereby the reader adapts his attending behavior according to his purpose for reading.

2. Analyzing

> "Only when we ask what the shaft of light that struck us is and how it struck us are we analyzing" (Henry 1974 p. 12).

The process of analysis plays a prominent role within Henry's (1974) theory whereby reading is taught as concept development. Henry's primary assumption ..."is that the act of reading is inextricably embedded in a thinking process, either in analysis or synthesis or in both of these processes combined" (p. 3). Secondly Henry assumes that the inherent skills in analysis and synthesis essentially remain the same throughout an individual's lifetime. As an individual's experiences broaden his cognitive processes become more sophisticated or refined.

According to Henry "whenever we break up a word or passage into parts we are analyzing. In analysis we always aim to separate for some definite reason, for some goal" (1974 p. 5). Students may be expected to analyze the story's content or form such as the analysis of the theme, plot, character or conclusion. A critical analysis may reveal to

the student how the totality of the message was initially woven together. Thus within the realm of analysis, students ascertain the internal structural relations of a story. This discovery of such relations includes the act of isolating, of picking out, and of selecting.

Henry views the processes of analysis and synthesis as working simultaneously with one another. He clarifies this by claiming that, "analysis (separating) encases synthesis (joining) when we want (purpose) to get to the nature of something, a poem or a story. On the other hand, synthesis supersedes and embodies analysis when we want to put together into a whole several separate parts or separate relations of a work (poems or stories)" (p. 7). An example of the former would take place when a student analyzes the leading character's motives in order to ascertain whether or not they were honest or trustworthy. In the latter situation the student might write a paragraph about honesty, relating his personal experiences with that of the leading character. In this case the student is reanalyzing the two viewpoints in order to create a newly acquired opinion. Henry adamantly points out that, "The quality of the synthesis will depend more on the skill of his reanalysis than on that of his initial analysis of each work...In other words, analysis for the sake of separating is not the same as analysis for the sake of combining" (1974 p. 11).

While Henry viewed the process of analysis in terms of story structure, numerous other researchers deal with analysis in terms of the decoding act in reading. Spreiter (1982) considers that analysis is the

..."cognitive process of attending to or focusing upon information selected, chosen or abstracted from all the information available ...both past and present" (p. 5). More specifically Cronin (1982) and Malicky (1982) consider that while attending was depicted as a more passive and receptive process during word identification "...analyzing is an active organizing force, and is employed in selecting visual information by the discrimination of its distinctive features, and then abstracting and organizing this information for further processing. In reading it may be viewed as the ongoing structuring of visual information from the instant the image hits the retina until recognition is made" (p. 62).

Within the reading situation the analysis of words is commonly referred to as structural analysis. In the past, structural analysis emphasized the readers ability to discern the minute differences between the distinctive features of individual letters or words. More currently however, the emphasis rests upon a larger unit of analysis; such as spelling patterns in addition to syntactic and semantic units.

Cronin (1982) indicates that to date there is little consensus about what should be considered as a unit of analysis however "...all theorists agree that some unit of analysis must take place because it is impossible for the human eye to perceive a block of print and abstract its meaning" (p. 64). There are two major opposing reading theories which each espouse what they consider to be the most proficient "unit of analysis" to utilize while reading.

Due to the vast amount of interest which was earlier generated within the area of visual discrimination, many researchers advocated, what was labelled as a "bottom-up" model of reading. A "bottom-up" approach to reading emphasizes the analysis of each letter or word that is read. The "bottom-up" view may be illustrated in an extreme manner when young readers are required to analyse the features of each letter by discriminating between the round, curved, straight, horizontal and diagonal lines.

Royer (1978) refers to the "bottom up" approach, which he labels as the "weak form" of comprehension, as making use of the reader's internal dictionary or store house of words. The child is depicted as looking up each word in his mental dictionary and then by stringing each word together, comprehension of the message is gradually attained. Royer cautions however that when readers use solely a "bottom up" approach of analysis they frequently leave the reading situation without ever comprehending the intended message.

Analysis or visual discrimination of individual word and letter features plays an important role in Smith's theory of reading. "A distinctive feature...is an element of a stimulus configuration that constitutes a 'significant difference' ...that enables a perceiver to eliminate some of the alternative categories to which the configuration must be allocated" (Smith 1978 in Cronin 1982, p. 64). Smith does however refer to his concept of "redundancy" which is information provided from a number of different sources while reading, in an effort to explain why the unit of analysis an individual chooses to utilize is

dependent upon his prior experiences with the letter, word or phrase. Mature readers possessing a sufficient amount of such knowledge are said to be capable of processing larger units of semantic or syntactic information, with a minimum of analysis (Cronin, 1982).

The analysis of larger units of meaning falls within the theory of the "top-down" model of reading. This theory suggests that skilled readers adept in their utilization of the higher mental operations are capable of analyzing or selectively distributing their attention simultaneously to both the linguistic cues and the textual meaning. In essence this larger unit of analysis requires merely a scanning of the most appropriate visual cues.

"Top-down" reading theorists indicate that good readers are capable, with great rapidity, of formulating tentative judgments as to what high potency words they will analyze or more closely focus on, realizing that not all words need to be analyzed equally. A reader decides if the word has a sufficient amount of semantic meaning, by focusing on what McConaughly (1978) refers to as the unique appearance of the total word. She propounds that better readers are capable of analyzing larger units of meaning by minimally focusing on the word's visual form.

Cronin (1982) asserts that both the "top-down" (analysis of semantic and syntactic units) and the "bottom-up" (analysis of letter, word or spelling pattern units) approaches come into play during a reading situation. The unit of analysis the reader elects to employ is dependent upon his prior knowledge of the subject matter, the language being used, his predictions and his purpose for reading.

Cronin cites the example whereby the reader is confronted with a technical manual of which he possesses a little knowledge and is forced to analyze the graphics more slowly and carefully than the reader who possesses a wealth of informational knowledge on the particular subject. She states that "however, the accessibility of the reader's memory store of knowledge about letter and word features will also determine the operation of analysis" (p. 65).

In summary it is the writer's opinion that within the context of reading the process of analysis is the selection of the most salient details within the letter, word or passage.

Referring to analysis in terms of the story structure Henry (1974) described the process of analysis as an act of separating or the dismantling of information for the purpose of ascertaining both the component parts and their relationship to each other. The analysis process according to Henry is one of the two major cognitive components in conceptual development.

Referring to analysis in terms of the decoding act Spreiter (1982) and Fagan (1982) suggested that analysis was the act of focusing upon selected aspects of the available information. Cronin (1982) purported that analysis was ..."the discrimination, organization and abstraction from visual information supplied by print" (p. 64).

A discussion of the unit of analysis a reader selects during reading was revealed in relation to the "bottom-up" and "top-down" theories of reading (Cronin 1982; Smith, 1978; Royer, 1978). It was considered that the reader's employment of either the "bottom-up"

(letter, word and spelling) unit of analysis and the "top-down" (syntactic and semantic) unit of analysis were dependent upon the reader's language and background knowledge in addition to his purpose for reading.

3. Associating

Francis A. Cartier crytalizes the concept of association by espousing that, "There is only one way in which a person acquires a new idea: by the combination or association of two or more ideas he already has into a new juxtaposition in such a manner as to discover a relationship among them of which he was not previously aware" (Peter 1977 p. 257).

In a similar view Oswald & Black (1978) refer to association as the process whereby the learner combines his already existing knowledge with the new incoming information in order that a meaningful relationship may be formed. The understanding that two or more things may go together or are connected in some manner facilitates an individual's memory and learning ability.

Gerhard (1975) a reading researcher, considers that during the act of association one idea leads to another idea or that one object brings to mind a similar object. During the reading process association takes place in a sound/symbol or word/meaning relationship.

For approximately 60-70 years within this century the behaviorists' theory of learning which stems from the belief in conditioning through association, was viewed by educators and researchers as the most accepted theory. Cronin (1982) states that "it is hardly surprising

then, that many of the "great debates" in the teaching of beginning reading during the same period concerned units of association: whole words with word label, letter patterns with speech patterns, or single letters and diagraphs with phonemes" (p. 66). Thus for the most part reading was reduced predominantly to the teaching of phonics - specifically sound/symbol association.

Although most reading researchers would agree that sound/symbol association is of great import for the beginning reader..."there is considerable controversy regarding the use of phonological decoding by proficient readers" (Malicky 1982 in Cronin 1982 p. 64).

Cronin (1982) states that researchers such as Goodman (1976) and Smith (1978) suggest that normally while engaged with text, skilled readers need not be continually interrupted with the task of linguistically decoding the print. Thus ..."the proficient reader bypasses phonological encoding, associating print to meaning, while the beginning reader has to go through the intervening auditory or oral steps" (Cronin 1982 p. 67).

According to Smith (1978) the semantic memory is stimulated upon contact with instantaneously recognized sight words thus providing the skilled reader with meaningful associations from the print. Hence the good reader, making use of his higher intellectual processes need not be burdened with the time consuming practice of making associations with each individual word in order to ascertain the intended meaning from the text (in Cronin 1982). It would appear therefore that the aforementioned researchers would support Fagan's (1981) assertion that

there are two major categories of association: sound/symbol and word/meaning association.

According to Fagan (1981) the process of association is defined as knowledge that two or more experienced elements are related by either meaning or sound. Sound association occurs when the reader for example associates the short and long sound of "a" with its written symbol. With respect to meaning association, instantaneous recognition of the word "nest", for example, may stimulate in the reader's semantic memory numerous associations such as "bird", "home", "eggs".

To elaborate further, Fagan (1981) has subcategorized the process of association into sign, assigned and reciprocal association. Characteristic within young children, sign association signifies the association of a word only when they are confronted with the physical object. Hence as the child observes an object he gradually learns to associate the word with the particular object and later with the object's function. Initially however the child is often unable to make a distinction between the symbol and the object it represents. Thus for example no separation is made between the word "dog" and the pet or stuffed dog the child is observing. Also children may have difficulty differentiating between the inherent features of two rather similar objects. Hence both dogs and sheep for example may be associated with the label "dog". As children mature they are more able to analyze objects into their distinctive features.

In a similar view Vygotsky gives credence to Fagan's concept of sign association by claiming that "once a child has associated a word

with an object, he readily applies it to a new object that impresses him as similar in some ways to the first. Potential concepts then, may be formed either in the sphere of perceptual or in that of practical, action-bound thinking - on the basis of similar impressions in the first case and of similar functional meanings in the second" (1962 p. 48).

Later assigned association occurs according to Fagan, as the child makes the association of a word with a sound or another word. Thus the child assigns the word "dog" to the sound "bow wow" or he assigns the word "dog" to the word "Rover". The word "chiwawa" may for example, stimulate the association of the words "cuddly animal". This would occur when a young child possesses only a minimal number of features for the concept of chiwawa. Thus the child has very little understanding of how and where the chiwawa fits into the scheme or classification of the dog family, but he at least understands one of the chiwawa's numerous features - that of being cuddly.

It is of great importance that the young reader possesses the knowledge of how to associate labels with objects, labels with labels and finally concepts with concepts. Without this understanding children may verbalize a word, which labels a particular concept, without possessing the associative understanding of the concept's numerous features or categorical framework. Thus without a complete associative level of understanding, young or less proficient readers often fall short of fully comprehending the printed word that signifies the concept.

Fagan employs the label reciprocating as meaning the converse of association. Reciprocating occurs, for example, when the child upon hearing the word "Rover" is able to reciprocate the word "dog" in his mind. With regard to spelling reciprocating may occur if the child spells the word "doll" as "dol". In this case the child is reciprocating the sound/symbol associations on a phonetic basis rather than on a letter by letter basis.

Humes (1978) who considers that association is the linking of equivalent information, also suggests that there are two types of association: coordinating and attributing. Coordinating refers to a transference or a "trade-off" between features from one label to another label. For example, one may transfer all of the features from the word 'tree' over to the word "imm", thus making the word tree equal to that of the word 'imm' (Fagan, 1981). In essence an individual groups or coordinates all information together under one package label. Attributing, on the other hand, is a separation of features. Some but not all of the features of a word are transferred over to another word. An example of such would be "they flew the faltat". One feature that may be attributed to the word faltat is that it is an object which is capable of flying (Fagan 1981).

In summary, all researchers cited above claim that the act of associating is a linking, joining or combining of information in order to ascertain a newly discovered relationship. Humes (1978) referred to association as the linking of equivalent information. With respect to reading sound/symbol association was viewed as a necessary task in the

beginning stages but was questioned (Cronin 1982, Malicky 1982 & Smith 1978) as to its importance by proficient readers. Smith advocated that the mature reader's instantaneous recognition of numerous sight words enabled them to frequently bypass the act of associating meaning with every element in the print. Fagan (1981) made reference to both sign and assigned association in addition to its converse labelled as reciprocating. Humes in a similar fashion to Fagan discussed coordinating and attributing as being two types of association. Association was also regarded as one of the initial steps within conceptual development.

4. Generalizing

"In logic, the impression is a generalization"

(Henry 1974)

The term generalization encompasses a rather broad category of meanings. Webster's New Collegiate Dictionary (1980) defines the process of generalization as 1: "a general statement, law, principal or proposition", 2: "the act or process whereby a response is made to a stimulus similar to but not identical with a reference stimuli" (p. 473). The term generalizing is regarded by the Dictionary as the making of general conclusive statements.

Expounding upon the initial definition from the dictionary Smith, Meredith and Goodman (1970) state that generalizations are always tentative in nature thus continually subject to revision or verification as either compatible or incompatible evidence is cited. Generalizations act as a frame of reference which may facilitate the direction for

further examination. In this case the term generalization, a conditional model of the world, is regarded as synonymous with either a working or proven hypothesis.

According to Henry (1974) generalizing in addition to comparing and classifying information is an "act of joining", a bringing together or a relating of information. Henry views generalizing as a union of information or concepts from two separate environments.

Henry, in a similar fashion to Smith, Meredith and Goodman, proffers that during concept development an individual initially examines all of the relevant information that is presently known in order to frame a generalized statement. Subsequently the newly acquired generalization is tested. It will either conform with the original concept or an alternate or revised concept will be formulated.

Utilizing the term "extension" in conjunction with generalization, Henry claims that an extension is "the moving out of a generalization (the newly formed concept) to ingest other elements or entities ...Extension therefore...is a mode of testing the limits of the concept" (1974 p. 40). Thus the further an individual can extend his generalizations, the clearer and more precise the concept becomes. Embracing this opinion Uznadze states that"...generalizing does not impoverish but enriches and deepens the image" (in Rawson 1965 p. 60).

Vygotsky (1962) further clarifies the above thesis by espousing that concepts are a generalized reflection of reality. He purports that "every thought is a generalization (p. 124)"... and "that from primitive generalizations verbal thought rises to the most abstract

concepts (p. 121)". He elaborates upon his belief when he states that "when the process of concept formation is seen in all its complexity, it appears as a movement of thought within the pyramid of concepts, constantly alternating between two directions, from the particular to the general and from the general to the particular" (p. 80).

Spitzer (1977) speaks of two categories of generalizations; response and stimulus generalizations. A response generalization is specifically regarded as the transference of knowledge into new environments. The individual in this case reacts to closely similar situations as if they were alike. Thus with regards to educational training, what the student learns in one area or discipline may be generalized or transferred over to another discipline.

As stated earlier, the transfer of learning is at the center or core of the problem solving process. To have acquired information for the sake of storing it would be rather fruitless. Hence knowledge would lie stagnant unless we were capable of generalizing it in a meaningful way to our numerous daily problems and personally motivated inquiries. Within the language arts children are encouraged within their daily activities to transfer the oral model of communication into the written. In order for reading comprehension to be attained students are frequently required to generalize information stated in one segment of the text to another segment. Within numerous circumstances the reader may also profit from his ability to generalize the content and/or form of one literary work with other similar works (Henry 1977). Clearly it is a major aim of our educational system to stress the importance of the transfer of meaning as being the primary purpose of communication.

Spitzer's second category of generalization labelled as stimulus generalization refers to the situation whereby certain stimuli such as objects, people, places, events are regarded as essentially the same. Often, however, young children will overextend the parameters of a situation. For example, a child may make the generalization that all men are daddies or that all four legged animals are dogs. This "over-extension" of the child's conceptual labels is normally referred as an "overgeneralization". Another example of overgeneralization may occur when the young child begins to acquire the concept of the moon. He may assume that the attribute or property of "roundness" is the sole criteria which defines a moon as a moon. Thus when the child generalizes his newly acquired definition of a moon (which is roundness) into another environment all round objects will subsequently be labelled as a "moon" (Lindfors 1980).

Clark (1973) further explains the concept of overgeneralization within her "Semantic Features Hypothesis". She states that, "children seize on some particularly salient (to him) perceptual feature of the object in question (four-leggedness), assumes that feature to be its "definition", and uses the term for objects possessing this defining feature (calling horses, sheep, cows and dogs "doggie") (in Lindfors 1980 p. 169). As the child's experiences broaden he begins to acquire more information about similar objects thus enabling him to extend the number of semantic features that he originally attached to his definition of a doggie. In essence he is now capable of differentiating among the various other animals which possessed the original four-leggedness feature.

According to Pearson & Johnson (1978) there is an inseparable parallel between experiential growth and semantic or vocabulary expansion. Beginning readers depend upon their experiential base in order to understand the meaning of the printed words, whereas more skilled readers are capable of utilizing the print as a way of building upon their meaning vocabularies. Pearson and Johnson espouse the belief that "since words represent concepts which reflect experience, common sense tells us that the principal contributor to reading comprehension is vocabulary knowledge. Certainly the processes and generalizations of word identification, and the many subskills of comprehension are crucial to continued reading development" (p. 37).

Similar to that of Spitzer and Clark, Uznadze (1961) purports that within a generalization "there is no rejection of the specific attributes...but a synthesis in which the attributes are preserved in the general concept" (in Rawson 1965 p. 62). Essentially Uznadze considers that within a generalization..."what occurs is the unification of specific concepts within the generic one" (in Rawson 1965 p. 62).

Fagan (1981) refers to a generalization as the extension of an individual's already existing associations into a new environment. Fagan, in this case, interprets the label "extension" as being synonymous with that of generalization.

Reading specialists Pearson & Johnson (1978) utilize the term "script" (Shank 1973) as a means of describing the child's past experiences or worldview (Smith 1975). Pearson and Johnson in addition to Fagan (1981) and Shank (1973) depict the individual as an

"information processor" capable of utilizing their "scripts" in order to formulate generalizations. The reader, for example, may extend or transfer his already existing or newly acquired world knowledge into another applicable domain, which in this case may be a story or passage he has recently encountered. Accordingly as a child reads a series of stories, containing similar story grammars, he may then form generalized associations between the stories' events, characters, moods or tones etc. One the child has generalized such information he is then capable of ascertaining the uniqueness and the commonalities that exists between different literary works.

The process of generalization according to Malicky (1980) plays an important role in what is a commonly known reading exercise labelled as "Finding the Main Idea". Advocating against this type of exercise, Malicky propounds that "readers do not go through a process of elimination after each paragraph to determine main idea; rather as they read they constantly relate one idea to another and by abstracting...[separating or singling out]...the similarities among ideas, they generalize from all the details. Finding the main idea involves a generalizing rather than an eliminating process, and it is much more efficient to help children work through this process than to let them learn to answer main ideas questions through trial and error" (1980, p. 2).

Fagan (1981) also suggests that generalizations are made when a child learns to perceive context, phonic, structural and glossary cues. With respect to phonetic cues, for example, a child who has learned to

associate the short "a" sound with the written letter "a", may subsequently be capable of generalizing the short "a" sound to the word "an", "and" and then "Andy". Thus the child's initial association of the letter "a" with its short vowel sound has been generalized into new reading situations. It is Fagan's belief therefore that reading instructors when focusing upon phonetic analysis, should introduce to their students, words that contain similar spelling patterns. Similar spelling patterns may facilitate the students' understanding of how to generalize the grapho-phonic cues upon contact with new and difficult words.

Another example of how the reader makes use of the generalization process may occur after he has made the association between the sound "shun" and the written syllables "tion" and "sion". The reader at this time may generalize the associated "shun" sound when pronouncing new words such as "function" or "tension". Further generalizations occur when the reader is capable of pronouncing the "shun" sound when it is embedded into multisyllabled words such as "fractionate" or "motionless". Word meanings may also be generalized when they are acquired in context. According to Fagan, the more contact with word or letter associations, the more ready they are to generalize into other situations.

Mature readers will formulate generalizations about the surrounding contextual cues in order to predict the meaning of an unknown word(s) in a sentence. The reader formulates tentative generalizations concerning the authors message. Initial generalizations or hypotheses are always

subject to reformulation as the reader acquires further information from the text (Smith, Meredith, & Goodman, 1970).

In summary this section has dealt with the numerous denotations reading and other researchers have attached to the label of generalization. The product of a generalization was referred to as universal, rather than a specific statement which is aimed at the majority or the whole. With specific regards to reading the writer has gleaned from the literature that the process of generalizing involves the combining and/or extending of once separate pieces of detailed information (letters, words, concepts) in order to ascertain a relationship of commonality.

Webster's New Collegiate Dictionary (1980) Smith, Meredith & Goodman (1980) and Henry (1974) all referred to the product of generalization as being the deriving of a tentative law or model of a concept, constantly in the position of being revised and or extended upon. Generalization was perceived as being a union or joining of specific ideas or concepts into a more general mode (Henry 1977, Uznadze 1961). Malicky (1980) considered that a generalization was the forming of relationships among ideas. According to Spitzer (1977) a generalization was said to be a reaction to analogous stimuli as if they were the same. Both Fagan (1981) and Spitzer (1977) regarded a generalization as also being a transference of information from one environment to another.

Fagan cited specific examples whereby the process of generalization facilitates the reader's understanding and pronounciation of words

possessing similar grapho-phonic and spelling pattern cues. In addition it was stated that the formulation of generalizations made concerning the surrounding contextual cues aides the reader's comprehension of unknown words within the sentence or messages.

5. Classifying

To date the process of classification or categorization as it may be termed, is probably the most widely researched intellectual process. Many researchers adamantly adhere to Bruner's (1956) proclamation that "virtually all cognitive activity involves and is dependent on the process of categorizing (1956, p. 246). According to Rawson (1965) reading is also a cognitive activity and thus is dependent upon the logical operation of classification.

Britton (1970) considers that, "Language is our principle means of classifying, and it is this classifying function that goes furthest toward accounting for the role of language as an organizer of our representations of experience" (p. 23). A word, according to Vygotsky (1962), does not relate solely to one object or event but to a category of objects and events. As the child learns the words of his language, they function as organizers, thus they become designative labels for a variety of categories of meaning. Words which represent an individual's concept of the world provide a generalized meaning for things that contain common characteristics. Words play an important organizing role at all stages of conceptual development. Accordingly, as an individual's concept of the world expands, so do the meanings that he attaches to the words that label those concepts. As language represents

the principle means of classifying and organizing experiences then the gradual development of classification schemes is an essential prerequisite in the evolution of concepts.

Bruner (1956) espouses that the process of categorization plays a key role in the development of concepts. His contention is that to learn, perceive, conceptualize and to make decisions is to categorize. Through the utilization of categorizing, individuals are capable of diminishing the complexity of their environments and reducing the necessity of constant learning, for new thoughts and experiences can be classified and stored in relation to existing categories. He believes all learning and thinking can be expressed in terms of categorization. In essence, to develop and recognize a concept is to establish a categorization, because concepts act as an organizing system which interrelate both past and present experiential data.

Bruner's (1973) extensive investigations regarding conceptualization have led him to hypothesize that the newborn infant has the potential to form categories and does so upon his interaction with the environment. Conceptual growth appears to involve a successive mastering of three forms of representation along with their partial translation, each into the other. During infancy, categories are initially formed through the mode of enactive representation or, in other words, knowing something through doing it. Later, through both the enactive and ikonic modes of representation, the child knows something through a picture or image of it. Finally, through a combination of enactive, ikonic and symbolic representation, the child knows something through a symbolic form such as language.

The young child continually interacts with his environment through any or all three of the enactive, ikonic and symbolic modes of representation. Prior to the entry to school, the preoperational child's symbolic representation normally takes the form of oral language. Within the first grade the child is introduced to a different form of symbolic representation - that of print. Upon contact with the oral or written form, the child is then able to symbolize the object in his mind. Labinowicz described this as, "written language is a representation of a representation. Being twice removed from reality, written language is the most abstract form of representation" (p. 1980, p. 114).

Sapir (1962) contends that language serves as a symbolic system that enables the communication of thoughts and ideas. Prior to the comprehension of the language-symbolic relationship, the environment must be simplified and generalized. This can be achieved as the child is able to make the associations of the symbols with the particular categories of activities and experiences.

From the viewpoint of Leach (1964),

> The physical and social environment of a young child is perceived as a continuum. It does not contain any intrinsically separate 'things'. The child, in due course is taught to impose upon this environment a kind of discriminating grid which serves to distinguish the world as being composed of a large number of separate things, each labeled with a name (in Rosch, 1976, p. 34).

In order for the child to formulate such a "discriminating grid" Lindfors (1980) proposes that the young child's, "What dis/dat" questions provides him with the knowledge of how our hierarchically structured language is semantically categorized and labelled.

Rawson (1965) goes to great length in discussing how the child's ..."primitive notions of names and their origin continue well into the period of learning to decode and interpret printed signs" (p. 21). Immature concepts would most likely alter the interpretation of the written message, says Rawson. From the ages of 5-7 the child regards a particular name as being situated within the object being labeled. Seven and eight year olds begin to dissociate the name from the object. Although it no longer is attached to the object, the name ..."contains in itself the quality of the object" (p. 22). By the age of 10 or 11 the child comprehends the arbitrary nature of the name or label. Rawson suggests that "to the extent that oral signs are not cleared of these primitive adherences, the child may be expected to have difficulty in discriminating between the sign and the thing signified in reading (1965, p. 22). Upon the initial introduction to the text the young reader, says Rawson, is confronted with information which has already been converted into a symbolic system. Such signs are viewed by the child as nonmanipulatable objects in space. Thus, suggests Rawson, "the point of departure for the child is therefore the sign and not the action (however carefully he has prepared for this moment of reckoning)" (1965, p. 36,37). While reading, the young child quickly learns that he is in total control of the operation and cannot depend upon the spoken word. Reading may be regarded therefore as a new method of reciprocation of information with the child's surrounding environment, which as Rawson claims, necessitates an alteration in the child's present cognitive operations.

The quality of information the reader is capable of assigning to the printed signs is related directly to their cognitive and conceptual level of development, claims Piaget. In reviewing both Piaget's and Bruner's work, Rawson contended that "abstract signs have been shown to have considerable power for inducing, supporting and even accelerating major cognitive reorganization" (1965, p. 39). The printed symbols can liberate the reader from the primitive concepts due to the fact that they can facilitate the summarization, organization and recording of the present concepts the reader is working with.

While the initial drive for cognitive reorganization commences with the relinquishment of primitive concepts and with the realization of concepts of the predictable or fixed characteristics of objects, Rawson claims that in addition,

> "the construction of intelligence proceeds on the basis of the control of the logic of classes and relations. In this process the mastery of the grammatical structures of the sentences by which such classes and relations are expressed is indispensable, not only the structures which occur in the spoken form of the language but also the structures which appear in the frequently more complex sentences of print" (p. 1965, p. 40).

According to Vinacke (1954) a concept is a stabilized or established classification. Therefore, due to the fact that the ability to construct mature concepts plays a major role in reading comprehension, the ability of the reader to formulate a classification system in turn facilitates his understanding of the printed message.

According to Russell (1956 in Inglis 1974), behavior which involves the apprehension of symbols such as print in either a perceptual or conceptual capacity may in many ways be considered as a categorizing

activity. It is the assumption of Inglis (1974) therefore that most likely the process of classification is closely related to both identification and comprehension in reading. She states that in essence the reader performs logical operations upon the raw material, which in the reading situation are the printed symbols. Summarizing her viewpoint Inglis (1974) asserts that, "Logical operations are not dependent on reading, but reading is dependent upon logical operations. Classification is basic to both processes. Therefore, the relation of the classificatory operation to reading is an important one. It is a necessary means for reading acquisition (beginning readers), and in a different way, a necessary means for advanced reading comprehension (mature readers) (p. 42). Cited within the research of Inglis are a number of studies that have dealt specifically with a relationship between reading and classification relationship. According to Bruner and Oliver (1962) less proficient readers more often utilized perceptual features such as color, shape, and size during concrete classifications, whereas more proficient readers tended in a more abstract manner to classify items according to functional criteria such as the object's use. Wickens (1963) found that more achieving readers were better able to initially abstract and then verbally describe the classified patterns arising from their abstractions. Wickens considered that because the language itself is comprised of related groups or categories, reading comprehension tests should include an examination of the reader's ability to abstract and classify the relevant textual concepts. In summary Inglis concluded from the research that indeed there is a

significant relationship between reading, comprehension and classification in that proficient readers consistently produced better results on classificatory tasks than less proficient readers.

Rawson (1965, 1979) like Stauffer (1976) propounds that, "the reading process is akin to the thinking process" (Stauffer, 1976, p.8). Rawson maintains that there is an interdependent relationship between the logical thought processes and reading comprehension. Both are viewed as evolving over time in a sequential manner as a result of the reader's continual experience and interaction with his environment. Patterning much of her work on classification from Piaget's Theory of Intellectual Development, Rawson views the classification process as a facilitator of reading comprehension. Specifically within her research, Rawson observed how different levels of classification and seriation employed during concrete situations could be transferred to more abstract and symbolic situations such as reading. She adheres to the position that ..."the classroom presents opportunities for the social exchanges that encourage operational thinking and reading provides for the extension of the thinking skills to organizing and remembering in another medium" (1979, p. 189). She contends that children who are given the opportunity to discover relationships on a concrete level are likely to have an understanding of similar relationships in reading. Miller et al. (1960) espouses that "a classification, once learned, is stored and may be retrieved and its relevant and efficiency as a higher order category examined in new contexts" (in Rawson 1965, p. 61). Rawson clarifies this important point by stating that "while the

specific stimuli in the two situations were not identical, the decisions and their defence required the same cognitive operations in each situation (1979, p. 194).

Rawson's considered opinion however is that reading problems may occur in conjunction with the regression of logical thinking when the child is initially introduced to the abstract written signs. Problems of this nature often arise in ..."response to the loss of concrete manipulation as a means of learning and to the reduction of social interaction accompanying a new learning situation" (p. 65). Investigations by Downing (1973, 1974) have shown that while children may read a selection with great fluency they may have little or no concept of what they have read. "These comparable forms of disability may have a similar etiology - loss of the ability to operate classificatory structures when the material to be classified is represented in abstract signs" (p. 65). Within her study, Rawson referred to three types of classification: simple class inclusions, additive groupings and multiplicative groups, each of which are formulated on a graduated continuum from the perceptual to a conceptual mode (Inglis, 1974).

According to Rawson, children who comprehend basic categories or class membership are considered to be performing 'simple class inclusions'. For example unrelated items such as blocks, cups and beads would be specifically categorized as three separate groups consisting of blocks, cups and beads. Simple trial and error classifications of this nature are referred to as horizontal classifications. Horizontal

classes are classes which are mutually exclusive and usually equal in their inclusiveness, thus an object and its attributes are inclusive of only one class or group. Although simple class inclusion groupings are not considered to be classification proper, Piaget advocates that true classification will develop out of these juxtaposed groupings.

With respect to the relationship between simple class inclusion and reading, Rawson claims that classificatory behavior of this nature, ..."appears in reading as the child lists the ideas in a paragraph before sequencing or nesting them or relating them hierarchically to a main idea. It is also apparent when two words are linked in meaning simply on the basis of their spatial proximity" (1965, p. 47).

Piaget proffers that during the concrete operational stage (7-11 years of age), children are capable of performing the classification process but purely on the basis of perceptual criteria. Children at this stage can more easily formulate vertical groupings whereby individual classes are categorized and recategorized in a superordinate - subordinate affiliated fashion. Rawson, refers to this type of simple hierarchical classification as additive groupings.

Additive groupings result in hierarchical structures with groups relating themselves to subgroups in superordinate and subordinate positions. In other words, categories which are embedded within one another are viewed as having a hierarchical relationship. The expansive categories, referred to as superordinate, represent ways in which objects may be regarded as similar, regardless of their individual differences. Those categories which are more precise and distinguishing are referred to as subordinate.

An example of a hierarchical classification would be:

Circles

red circles		blue circles	
large red circles	small red circles	large blue circles	small blue circles

According to Piaget (1964), the child's comprehension of class inclusion is a deciding factor as to whether or not the child has reached the level of concrete operations in classificatory skills.

Rawson (1979) probed further into the relationships between additive groupings or hierarchical classification and reading by focusing upon the classificatory nature in which letters, words, sentences and paragraphs are constructed. Initially young children often view a word as an entity in itself and inclusive of only one sound. Upon contact with the spoken or printed word, children discover that words are comprised of elements or units. Initially, for example, consonant units may be singled out according to their distinctive features such as consonants containing curves. Later associated labels or names are given to the units such as "the letter c". Thus units which contain common features will be categorized into a labelled group or class such as "consonants". In terms of hierarchical classification Rawson explains that ..."the child's attention will move from single units whose distinctive features are known, to the superordinate class that includes these units - the class consonants, vowels, letters - and down to the subordinate classes, lax and tense vowels, voiced and whispered consonants..." (1979, p. 204).

Many children however have difficulty applying these primary logical operations of hierarchical classification when they become initially acquainted with the reading process. Britton purports that "words are themselves classifications, and the means for building up categories" (1970, p. 41). Thus most words during vocabulary instruction are taught as "class" words. The word "car" for example is inclusive within a hierarchically ordered class of objects such as a set of objects of different makes, models, colours and sizes; a set of objects possessing four wheels; a set of objects utilized for transportation; or a set of objects which operate on gas or diesel. Although not all of these relations need necessarily be dealt with, Rawson suggests that "what appears to be important in teaching reading is that the emergence of such relations be allowed in thinking..." (p. 66). In reference to reading Rawson states that "operations in classification remain implicit in reading. An author assumes that the meaning of a class name and the class inclusion relation (a duck is a bird) are understood and will be supplied by the reader. Responses to the classification questions suggest that some readers are unlikely to recognize this operation in reading" (1979, p. 198).

Adults employ words with the ability to 'objectify' their symbols in an abstract manner which is often totally outside the realm of the child's concrete subjective concepts for words. Children with impoverished conceptual understandings for words have more difficulty in reconstructing the meaning as symbolized by the print. More fluent readers, however, emphasize the abstract or class attributes of the word

meanings, thus reflecting a knowledge of an underlying hierarchy of related concepts. By focusing on the quality of word meanings as such, children are encouraged to produce classifications of meanings which provide a more complete foundation of their existing and newly acquired concepts which in turn provides them with a greater wealth of knowledge to bring to the text.

Rawson supports Piaget's theory that children, when dealing with the logic of class inclusion, have difficulty comprehending the quantifiers "all", "some" and "none", ..."and establishing the correct positions of these words in a statement such as, "All the A's are some of the B's" (p. 50). Within class inclusion lies the understanding of logical relations. In order to fully understand logical relations the child must exhibit the proper use of the class inclusion quantifiers (all, some). This logic of classes and relations, as it gradually develops, may be applied to the understanding of relations in simple basic sentences and to relations expressed by embedding sentences and by conjoining them" (Rawson, 1965, p. 2). Thus in a linguistic sense the child acquires the understanding of logical relations when he is capable of comprehending while listening or reading to, for example, the relational statement: "Susan is the cousin of John".

In order to comprehend the meaning of a sentence as a whole, an individual may first understand its partial relations. Accordingly, the words that make up a sentence may be viewed as individual concepts, each possessing a class label and each having inclusion relations. The relation between the words or class labels constitute the structural

base of the sentence, thus the sentence is viewed as a whole-part relation. Rawson clarifies this notion by stating that "the implication of a whole-part relation is that there will be subordinate units, parts that relate to each other and function together in giving meaning to the sentence, the whole" (1979, p. 210). Rawson refers to such subordinate units as noun and verb phrases, which may be further classified into prepositional phrases, determiners or adjectives.

As a child formulates the meaning for words and sentences, or further constructs the hierarchy of concepts, he learns in essence to classify and order items into categories so as to generalize meanings that exclude or include common characteristics. The student can then more proficiently extract and organize the information, not only so as to discriminate between the relevant and irrelevant details of the passage, but to discriminate the main idea from the relevant supporting details, in essence understanding how to determine the whole or the gestalt. Bond and Wagner (1966) purport that the organization of a paragraph is a fundamental element of reading comprehension (Inglis, 1974). Rawson (1965) propounded that there are important parallels between the intellectual process acquired in classification and the series of steps required in reading to find the "main idea" of a paragraph and to indicate the relationship of the supporting ideas to principle ideas. There is a necessary survey of the material as a whole; the search for possible dichotomies; the downward search for the subordinate parts of the organization.

Once a child is able, on a concrete level, to predict the serial order and multiclassification system of manipulated objects, a transference can be made to a more abstract or combinational level of reasoning, as required in reading comprehension.

Upon learning to read, children are expected to deal with the linear nature of the print. Sequencing occurs as the reader attends to the letters and words which are situated in a left to right progression. Cronin (1982) proposes that "sequencing problems may arise at the letter or word levels. The single distinguishing feature of many words is letter sequence, e.g. bran for barn or clam for calm; thus, failure to sequence letters may result in comprehensive problems" (p. 65). Classification and serial strategies also facilitate comprehension of the internal structure or the sequentially organized outline of a story. This stimulates the child's story schema or preconceived expectation of the story's framework. Inductively established, knowledge of story grammar facilitates the reader's prediction and recognition of the progression of time, place, ideas, events and problems to be solved in addition to forecasting the author's use of tone and mood. This procedure, in addition to familiarizing children with the story structure, should enhance the child's ability to more precisely comprehend the relationship of the relevant details, potentially enabling him to extract the central idea.

Rawson refers to the third type of classification as "multiplicative groups". Like that of additive groupings, multiplicative groupings also fall within the category of vertical

classifications. Within this framework multiplicative groupings may be regarded as a relating of already constructed classed in order that new classes may be formed.

Multiplicative groupings, which are acquired from approximately seven to eight years of age, are manifested in the form of either a matrix or an intersection. An example of matrix may be depicted on a concrete level by having children manipulate groups of red, blue, round and triangular shaped blocks. The new matrix which may be constructed would be, red circles, blue circles, red triangles and blue triangles. This matric would be depicted as;

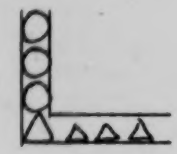
	RED	BLUE
CIRCLES	○ ○	○ ○
TRIANGLES	△ △	△ △

An example of utilizing multiplicative matrix classification within a language situation would be manifested by the child's ability to construct and comprehend a sentence embedding a three-way matrix such as:

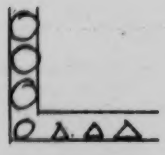
"The blue triangle blocks are on the table."

Within the form of an intersection, adjective noun constructions were dealt with by Rawson, at both a concrete and at a reading level. Within the concrete situation, children were asked to look at the categories of large circles and small triangles. Upon request to join the groups in order to "finish the pattern" children could either place

a small circle or large triangle at the point of intersection. In this situation the child was asked to abstract the criterial attributes and then multiply these attributes in order to construct the class of intersection, which may be depicted as:



or



Within a similar reading situation, Rawson provided the children with a passage that described an old city with two streets that intersected or met at the corner. The people on one street set rafts outside their doors while the people on the other side set out brightly painted yellow treasures. The family who resided at the corner or intersecting point of the two streets also wanted to display something that manifested their inclusion on both sides of the street. Children were asked, what was one item the family could decide upon so as to display something in front of their home. The children could respond, "a yellow raft".

Also, within oral and written language situations understanding of multiplicative classification enables the reader or listener to comprehend complex and compound sentences and those sentences which are comprised of two quantifiers, such as:

"The children who are tall and in the grade six class will be required to stand at the back row".

Inglis (1974) in a brief outline has captured the highlights of Rawson's work concerning the utilization of classification while reading. She delineates Rawson's suggestions as follows:

1. hierarchical classification
   a) to develop meaning
      e.g. primitive level - object name;
           mature level - object names and relations
   b) to develop main ideas
      e.g., level 1 - properties
            level 2 - similarities and differences
            level 3 - hierarchical system properties
2. multiplicative classification
   a) to understand embedded clauses
   b) to understand complex clauses
   c) to understand complete articles
   d) to understand sentences with two quantifiers
      (e.g., The ones who are early and in line will be able to see the play.)
   e) to understand compound sentences
      (i.e., conjunction, disjunction, and negation)
3. all classification types
   a) to make outline formats

(Inglis 1974 p. 37, 38)

In brief, a number of reading researchers have observed how the process of classification plays an important role within all aspects of reading.

In a view similar to Rawson's, Gerhard (1975) espouses that reading comprehension can be improved upon through the process of categorizing. He asserts that readers must be provided ample opportunity in "1) sorting or grouping after careful observation, 2) recognizing the common characteristic(s), and 3) labeling accordingly." (p. 5). It is proposed that these experiences be dealt with in the concrete before they can be fully understood in the symbolically abstract, such as reading and writing situations.

Gerhard devotes much time to the explanation of how the process of classification is responsible for the isolating, collecting, organizing and integrating of information into single or topic sentences, paragraphs and essays. Gerhard maintains that while reading a paragraph which consists of many levels of ideas, individuals must have an understanding of not only the similarities and differences but the connection between information, such as, which statements are more specific and which are more general and which details are relevant and which are irrelevant. During the reading process, classification skills enable the student to discover and understand how the ideas communicated in both reading and writing situations are categorized in a hierarchically organized manner. Thus in conjunction with Rawson's (1979) viewpoint of classification and reading, Gerhard (1969) states that "upon contact with the text a reader's...attention moves from the

initial unit up to the superordinate unit and down to the subordinate units" (in Rawson, 1979, p. 204).

Smith (1971) believes that, "every aspect of reading can be seen as a process of categorization" (in Inglis 1974 p. 35). Thus he views that within the linguistic decoding and comprehension of the print, the reader is continually required to formulate groups or classes of some kind. With respect to decoding, for example, the letters "D" and "d" belong to the class called 'd'. The letter 'd' also belongs to the superordinate class of consonants.

With respect to vocabulary development Smith states that all word meanings acquired through either physical or symbolic experiences may be categorized. For example, the word "tractor" is not only inclusive of a particular class of letters and sounds but is also inclusive within a specific class of farm equipment or within a broader class of transportation devices.

Smith also advocates that the interrelations formed between word categories are always viewed as an open-ended process enabling the individual to further interpret and predict new categories. For example, the word dog, from a child's experience, may stimulate numerous meanings and interpretations such as animal, pet, Collie, Rover, bark, or loyal. Hence, each category constructed possesses some similarities and some differences; the differences being either mutually exclusive or hierarchically related. As categories for word meanings evolve the reader can more successfully comprehend the author's intended message.

Syntactic features in addition to semantic features also play a role in the individuals' construction of word classes. Inglis (1974) depicts an example whereby the reader constructs a category consisting of the auditory similarity between the words to, too, and two. Upon listening to or reading these words in the text the individual is required to reconstruct their initial category into three new categories according to word meaning. In order to formulate these new categories the reader must also have an understanding of how each word has its own unique function within a sentence. Thus, new word categories may be formed on the basis of both semantic and syntactic features. Therefore according to Smith, readers engaged with the text are required initially to construct categories of word classes, then ascertain the interrelationships between these classes and finally on the basis of syntactic and semantic features word classes are modified or extended.

Pearson and Johnson (1978) refer to a word and concept as being synonymous terms. They graphically portray a set of word relationships, similar to the above example mentioned by Smith, through a representation labelled as a semantic map. With respect to the example of a "dog", the word "dog" belongs to a class of things labelled as "animals" in addition to a class of things labelled as "pets". Within Pearson and Johnson's theory "such relations are called class relations, implying that the stimulus concept belongs to the class of things denoted by the associative response" (Pearson & Johnson, 1978, p. 34). The labels "Rover" and "Collie" are termed according to Pearson and Johnson as example relations. Collie represents another category while

Rover represents a particular dog, but both labels may be regarded as examples of dogs. Example relations such as the word "Collie" are reciprocal to class relations, such as the word "dog" due to the fact that while the word "dog" is a member of the class of animals it may also be considered an example of that class. Reciprocally, while "Collie" is an example of a dog it is also inclusive of the class of dogs.

Pearson and Johnson's third set of relations, known as "property relations", refers to the concept's properties or attributes. Hence, animals require food and oxygen, pets are normally domesticated and dogs bark and are usually loyal. Accordingly the property relations are always interacting with the class relations. Espousing that knowledge of vocabulary is a contributor of principle import to reading comprehension, Pearson and Johnson contend that although

> ..."it is fashionable and indeed important - to be concerned with syntactic structures and phonological relationships as important planks in bridging the gap from printed surface structure to the writer's or reader's own deep structures, we still hold that without words these are meaningless...We believe that the more words a child knows the meaning of and the greater the child's vocabulary flexibility and precision the greater the child's ability to comprehend what is read" (1978, p. 37).

Lastly, Henry (1974) who views reading as concept development refers to the interrelated logical processes of conceptualization as being the act of 1) joining 2) excluding 3) selecting and 4) applying of the written symbol. According to Henry "the total movement of these operations is the logical process in the discovery of relations and the invention of structure called classifying" (p. 16). Within the reading act, Henry views the child as combining and separating information from

the text in order to create a tentative classification or set of relations. By comparing and contrasting these former classes, new trial classes of information are constructed. Through higher levels of abstraction the newly formed classes can now be related to one another thus, forming a structure or a concept. Henry states that, "The product is a lattice or structure of relations: this is the concept as developed on the basis of the instances and classes dealt with" (1974, p. 85).

In summary it has been discussed how there appears to be a close relationship between classification and the reading process. Inglis (1974) maintained that reading is dependent upon logical or mental operations, but that these operations; of which classification is inclusive, are not dependent upon reading. Inglis (1974) cited numerous pieces of research that supported the claim that more proficient readers produced superior scores on classification tasks than less proficient readers.

Within her research, Rawson observed how classification strategies, discovered at a concrete level, facilitate classificatory behavior at the abstract level of the reading act. She asserted that the same cognitive operations were required at each level. Rawson referred to three major types of classification strategies: simple class inclusion, additive groupings and multiplicative groupings, each of which, in addition to the reading process, are developmental in a sequencial manner and each of which are interdependent upon each other.

Vinacke asserted that a concept is in essence an established classification. As a conceptual understanding of what the printed sign represents it is an essential pre-requisite to reading comprehension. It has been suggested how directly or indirectly classification strategies may facilitate not only reading but all aspects of language comprehension.

Letters, words, sentences and paragraphs are constructed in an additive or hierarchical fashion. The letter "c", for example, is inclusive within the class of consonants containing curves or just the class of consonants (Rawson 1965, Smith 1971).

According to Britton (1970) and Vygotsky (1962), words themselves are categories for objects and events. The author assumes that the reader comprehends that a car is a vehicle, or in classificatory terms, the reader comprehends the meaning of a class name in addition to the class inclusion relation.

Readers must also have an understanding of the grammatical structure of a sentence of which classes and relations are expressed. The sentence, "Keir is the brother of Jesse" manifests the understanding of logical relations. Knowledge of multiplicative classification enables the reader to comprehend sentences with two quantifiers as well as complex and compound sentences.

Rawson purported that the reader must have an understanding of class inclusion and additive groupings in order to list, sequence and relate the information hierarchically to a main idea in a paragraph or passage.

Similar to that of Rawson, Gerhard (1975) contends that reading comprehension can be ameliorated through the employment of the classification processes. Understanding of the hierarchical nature of ideas within a passage enables the reader to distinguish between information which is more general and that which is more specific.

Bruner would most likely agree with Smith's (1971) hypothesis that virtually all realms of reading can be viewed as an act of classification. Smith regarded the reader as organizing letters and words into classes or groups in order to identify, interpret and predict the written message. In order to receive a more complete understanding of the text, the reader further categorizes and interrelates word groups according to their semantic and syntactic features.

Extending the views proposed by Smith, Pearson and Johnson (1978) have depicted the relationship between word categories and what they label as a "semantic map". Within the semantic map, class relations, example relations and property relations are graphically portrayed as the intermeshing of the various levels of word meanings. According to Pearson and Johnson, the evolution of concepts or word meanings plays a role of paramount import in enabling the individual to comprehend what is read.

Henry (1974) espousing the need to look at reading as concept development referred to the act of joining, excluding, selecting and implying as being the classificatory processes utilized during conceptualization.

Thus, it can be stated that there is a positive relationship between classification ability and reading comprehension but as Inglis points out, "the exact nature of the relationship...is a matter of speculation" (p. 44). Although Rawson purported that the process of classification facilitates reading comprehension and Smith maintained that all aspects of reading are in actual fact the process of classification, it can be said that all of the cited researchers have agreed upon the fact that classification plays a paramount role in the growth of concepts, which in essence, is a fundamental basis of reading comprehension.

6. Synthesizing

There are many different denotations attached under the label of synthesis. According to Harris and Hodges (1981) an act of synthesis is "forming a whole, either concrete or abstract, from the logical relation of parts" (p. 321). Using the term synthesis synonymously with that of generalization, Massialas (1976) referred to this process as the interrelating of two or more events or factors, so that they are applicable in all similar cases, times and places. Syntheses as in all mental processes is open-ended, thus, it is subject to revision or modification as new information is acquired.

As aforementioned within Vygotsky's (1962) theory of conceptual development, true or genuine concepts are formed only when both analysis and synthesis are working together. Synthesis, a uniting of information, occurs when an individual draws together phenomena which share common characteristics.

Henry (1974), considering reading to be concept formation, maintains that reading takes place within the thinking processes of analysis and synthesis. Like Vygotsky, Henry considers synthesis as an "act of joining". According to Henry, the new logic, viewing concept development as an act of synthesis, also views the teaching of reading as an act of synthesis. It is advocated within this new logic that to acquire the understanding of the synthesis process within the written mode, provides a more proficient method of learning to read.

Henry perceives conceptual development in reading as a form of synthesis which comprises both the discovery of relations and the invention of a structure (which is the interrelating of the discovered relations). The discovery of relations, considered to be the first step in concept development, is a constructed union of previously separated pieces of information. As aforementioned in the section on analysis, a student must initially analyze separate works before a synthesis or relational discovery can take place. During the synthesis act however there lies another type of analysis: an analysis of purpose. Thus within synthesis there is a reanalysis pursuant to a specific aim or purpose.

Strategies such as comparing and contrasting different works may guide the quality of the relational discoveries. Henry points out that such strategies may guide the synthesis but they do not necessarily secure its quality. Making comparisons as a strategy to arrive at a synthesis involves a purpose so as not to merely end up with a list of likenesses and differences. Henry claims therefore that it is incumbent

upon the reader to not only ask himself why two seemingly different pieces of information may be joined but more importantly why do some segments of the information deserve to be combined while other segments deserve the right to remain as isolated entities.

Contrasting emphasizes the logical differences among things. It includes such operations as separating, excluding, conflicting, discriminating choosing. According to Henry, "The pupil should be so trained in reading that he perceives separation in one sense as a strategy toward synthesis (ripping off all accretions until the pattern is clear) or a strategy toward the most rational or artistic or expediant or normative choice" (1974, p. 39). As indicated in the section on classification the above strategies are inclusive in the classification process. A discussion of these strategies has been inserted within this section due to the manner in which Henry so adamantly stresses their inherent function within the synthesis process.

According to Henry, the second step of concept development known as the invention of structure, pattern or "lattice" (as referred to by Piaget), is the relating of discovered relations. "We invent a lattice because what is erected is not in the several relations being joined, each relation being held together by a level of abstraction that we ourselves must invent" (Henry, 1974, p. 13). Thus this evolvement of a structure or relation is a concept. It is Henry's belief that the creation of a structure of relations is the major aim for reading as concept development. Accordingly Henry propounds that, "Reading for concept development may be defined as making one's way through printed

and written language in such a manner as to seek out a number of relations and to put this growing set of relations into a tentative structure" (1974, p. 4).

Henry clarifies his philosophy by stating that meaninglessness is courted through the analysis of a succession of separate literary works, whereas, the synthesis or joining of a series of previously unrelated works develops a pattern or trend which creates an understanding of an overall focus or theme. Henry proffers that "...the outcome, the product, the decision, the plan, the attitude, the meaning that the pupil events - each of these is a set of relations, a structure that the pupil puts together. All are modes of synthesis" (1974, p.8). As in all thinking processes, a synthesis is a tentative, imaginative and openended judgement ready with the advent of new data to be revised and modified. Teaching reading as synthesis is a creative act for the product of joining supersedes any of the elements within the material read.

According to Fagan (1981), a synthesis is the organization of features one has attended to by focusing on a particular feature. He suggests that often young children see things in an additive fashion, not always capable of focusing on the information, event or item as a whole. To synthesize, according to Fagan, is to sift through various information in order to ascertain the major aim or focus. A synthesis facilitates the reader's understanding of the stories "main idea".

Fagan's (1980) definition is:

> A synthesis statement is a compilation of at least two units of information. It may not contain either of the specific units summarized but may be expressed in a hierarchical or superordinate category or by a label generalizing the events summarized, such as the main idea, theme or moral.

He further clarifies that an "erroneous" synthesis is "information from different units of the text which are (i) designated by an inaccurate superordinate referent, or (ii) generalized in a way which does not convey the gist of the passage" (p. 10).

According to Fagan (1981) synthesis while reading can occur at three different levels; at a sentence level, cross sentence level and at a passage level. While synthesizing at a sentence level the reader focuses solely on the meaning of one individual sentence at one time. A reader synthesizing at this level is most likely comprehending from a "bottom up approach". Thus the reader at a sentence level focuses solely upon the processing of letters, letter clusters and words until a store of contextual information can be recalled (La Berge & Samuels, 1974).

Readers synthesizing at a cross-sentence level are able to coalesce the thoughts of two or more sentences into one statement. The reader also groups the information from a few sentences together when recounting or remembering the content of a story. Synthesis at a passage level requires the readers to focus on the entire passage at one time. This is the highest level of synthesis, according to Fagan, for the reader goes one step higher than the actual information available. In other words, the reader relys more on his prior knowledge in order to relate to the story a whole schema of stored information. His

conceptual knowledge enables him to formulate hypotheses about what is being read in order that he may abstract the major focus of the passage. One may label this a "top down" reader (LaBerge & Samuels, 1974), whereby the reader's prior knowledge and cognitive strategies enable him to more fully control the reading process.

Fagan discusses how people most often speak in a fragmented fashion; accordingly a single idea or sentence level synthesis is most often employed. When individuals are capable of synthesizing larger units of information at one time they are more equiped as readers to comprehend the selection's meaning as a whole.

Throughout most stories, articles, or any reading material cues are made available in order to aide a more facile extraction of the thematic focus or main idea. There are two major types of cues or organizers , within text organizers, and outside text organizers.

Within text organizers, which are an essential part of the text, are again divided into two groups; relationships within sentences and relational connectives. Initially a reader must abstract a focus of the relationships of words in a sentence in order to ascertain the grammatical function, such as subject, verb or object. Secondly, two types of relational connectives are focused upon; referential connectives and logical connectives. "Referential connectives refer to previous information, that is they have an antecedent (a specific noun or clause)" (Fagan, 1980, p. 10). Examples of referential connectives may be pronouns (proform; he, his, that and relative; which, who), complementizers (that), synonyms (sharp, keen) and inclusions; (it,

everything, this custom). Logical connectives relate two two or more ideas or syntactic propositions such as in conjunction (and), temporal disjunction (after, before), causality (because, therefore), contrast (less than, equal to) and condition (if...then). Students possessing an understanding of these word relationships and connectives are better able to more quickly comprehend the language the author uses to communicate his ideas.

Outside organizers or clues are added embellishments such as titles, headings, italicized and underlined words. which the author utilizes in order to communicate his ideas more effectively. The title "Grizzley Bears", for example, stimulates the reader's already existing schema or background knowledge pertaining to that subject. An italicized or underlined word notifies the reader to attend to that section more carefully. Headings and subheadings such as hybernation, eating habits. provides the reader with an organized layout of the material being presented. In this manner the pupil can focus directly on the area of information that is most relevant to him at that time. Thus outside organizers enable the reader to moce rapidly sift through vast amounts of material while keeping them on the alert for important upcoming information.

In summary, the process of synthesis has been diversely depicted as being a major focus, an aim in its totality, a central theme or main idea, and a structure of relations. Gleaned from the literature, the writer has ascertained two commonalities which appear to be inherent in each of the researcher definitions of the synthesis process.

Firstly, synthesis is viewed in all cases as being in one manner or another an "act of joining". Both Vygotsky and Henry advocate the act of joining or synthesis as taking place in conjunction with the act of separating or analysis. Each is dependent upon the other in order that genuine concepts can be formed. Fagan discussed how the compilation or joining of units of information facilitates the extraction of the main idea, theme or moral. Fagan also discussed how synthesis can be viewed at three different levels: sentence, cross sentence, and passage level synthesis. Both outside and inside text clues were also discussed as being organizers that facilitate a more rapid synthesis of the material contained within the story or passage.

Henry (1974) viewed synthesis as being a process of inventing a structure which in essence is the relating of relational discoveries. Newly acquired relations or classes are related to one another through a broadening of the levels of abstraction until the structure or concept is attained.

Secondly, it has been emphasized by all of the researchers that the process of synthesis directly stems from and is thus directly dependent upon the process of classification. Harris & Hodges (1981) stated that a synthesis or "whole" is formulated after the parts have been logically related. Similarily speaking, Vygotsky (1962) referred to a synthesis as a drawing together of phenomena which have been classified as sharing common characteristics. Henry (1974) maintained that a synthesis was the combination of already analyzed (compared and contrasted) works. According to Fagan (1981) both analysis and classification dissect and

break down information into its constituent parts, whereas, synthesis summarizes various classes of information and reconstructs it in a manner that was previously implicit or nonexistent.

7. Predicting

Within the field of reading comprehension, the process of prediction is probably the most widely researched and accepted mental operation. Most specifically the psycholinguistic theorists (e.g., Goodman, 1970, 1976 & Smith, 1975, 1978) refer to prediction as being the core of comprehension and thus playing a key role in assisting students in becoming more proficient readers.

Within a reading situation prediction involves the individual's experiential background knowledge in conjunction with his knowledge of the language and the task at hand. According to Cronin (1982) it is those reading researchers who emphasize the importance of the reader's prior knowledge, who in turn stress within their reading comprehension theories the process of prediction.

Smith (1975) regards the human brain as being a system, which, as a result of our daily experiences, is an internally consistent and organized model of the world. Our theory of the world, which is a housing of all of our thoughts, is a summarized account of our past which enables us not only to understand the present but to predict the future. Thus the theories in our head enable us to make sense out of our world.

We carry with us, expectations about every experience or activity we take part in throughout our daily lives. According to Smith these

moment to moment expectations are a result of our theory of the world. Smith (1975) deliberately uses the term theory "because the theory of the world that we have in our heads functions in exactly the same ways as a theory in science, and for exactly the same reasons (p. 79). Scientists must have theories in order to summarize the clutter of both the past and presently incoming data. Scientists also utilize theories in order to interpret and make sense of new incoming data that is to come.

Based upon generalizations from prior experiences to new and present situations, people continually anticipate the outcomes that may occur. In order for our experiences to make sense the new information must be assimilated and slotted into a suitable mental schema so that it fits within a set of expectations. If however, the new information does not concur with our theory of the world an unstable situation arises. At this point we elect either to reject the incoming information or accommodate the information in a manner that enables us to remodel or refine our initial theory or mental framework. According to Piaget once the fresh information has been either assimilated, accommodated, or disclaimed our internal system of knowledge may once again find itself in a state of equilibrium.

It is Smith's opinion that comprehension, which, in essence, is the act of making sense out of a printed message, is dependent upon the process of prediction. Smith defines prediction as the asking of questions. He states that during the act of reading the reader is continually asking questions as to what subsequent alternatives are

likely to occur. Comprehension occurs when the reader obtains the appropriate answers to such questions. Accordingly Smith believes that only the reader himself can judge whether or not he has comprehended the printed message.

Smith advocates that through prediction the reader utilizes his background knowledge in order to reduce the amount of visual information or print that he is continually required to process. Within the reading situation prior knowledge as previously mentioned refers to the individual's understanding of both the oral and printed language in addition to an understanding of the relevant subject matter. Smith refers to such prior knowledge as "nonvisual information". Smith advocates that there is a "trade off" during reading between the nonvisual and visual (print) information. He asserts that "the more nonvisual information you have when you read, the less visual information you need"...Conversely, ..."the less nonvisual information you have when you read, the more visual information you need" (1975, p. 14). Also advocating the importance of the reader's nonvisual or background knowledge during reading, Goodman (1975) states that, "The apparently proficient reader may in fact be due to more successful prediction and hypothesizing, rather than more careful use of visual information" (in Cronin, 1982, p. 69).

In keeping with this line of thought, Ellis (1976) makes reference to the controlling of variables as one of the important aspects inherent in the prediction process. The controlling of variables, not normally thought of in terms of reading, in actual fact plays an important role

within the process of predicting. It would be impossible to make a logical prediction in a reading situation, if the reader had no control of the numerous variables that he must contend with at one time. If the reader had no authority over the selection of the most relevant graphophonic cues for example, he would find himself dealing with the obstacle of having to attend to each and every available cue on the page. In this case the reader would be so overloaded with decoding he would never reach the meaning intended by the author.

In discussing how the process of prediction facilitates comprehension, Smith draws an excellent analogy between the reader and the driver of a car. He depicts a skilled driver as one who is capable of automatically projecting his car into the future or desired destination. An unskilled driver on the other hand tends to be more cautiously aware of exactly what the car is doing from moment to moment. With respect to reading, a skilled reader also focuses his attention on the desired destination - which in this case is to acquire meaning from the print. Meaningfulness, according to Smith diminishes the number of available language cues or specific features within a word the reader needs to focus upon. A reader who has been understanding the author all along may even be able to grasp the meaning of the entire phrase after identifying only the initial one or two words.

The fluent reader having an understanding of the grapho-phonic system within our language is cognizant of the fact that words are comprised of predictable sequences of letters as opposed to a random sequence. In addition, some letters, such as vowels, occur far more

frequently within a word than other letters. Thus the reader can guess or predict in many instances which letters constitute the words he has quickly glanced over. "If the reader did not rely on the redundancy inherent in print, reading would be slow and restrained" (Cronin, 1982, p. 69).

In order to aid prediction the proficient reader organizes the detailed bits of visual information into larger "chunks" of meaning. Accordingly the reader's mind is elevated from the task of storing masses of material and is thus required to focus only upon larger and more meaningful units of information.

The experienced reader keeps an eye ahead of the words as units that his brain is actually processing at a particular instant in order to check..." for possible obstacles to a particular understanding" (Smith, 1975, p. 84). Adhering to this viewpoint, Gerhard (1975) espouses that in order for intelligent reading to take place, an individual must be equipped with the understanding of how not only to predict but continually check his predictions against that of the actual message.

Thus, in essence, the fluent reader's interdependence between his prior experiences and his knowledge of the language (graphophonic, syntactic and semantic structures) facilitates his capability of processing several messages simultaneously, thus he predicts the upcoming message while the present message is being linguistically decoded.

The unskilled reader, on the other hand, is incapable of forming predictions due to the fact that all of his attention is being directed solely to the decoding of the present message. Smith refers to the reader in this case as suffering from "tunnel vision", which is caused by an inundation of visual information. Thus when a reader is so preoccupied with decoding every word, assimilation and meaning become secondary tasks.

Smith refers to prediction as an act of "informed guessing". The word "guessing" may be appalling to some reading educators if it is ..."regarded as synonymous with a reckless lack of thought" (Smith, 1975, p. 67). The term "guessing" brings to mind an ambiance of "trial and error", an ambiance which permits the child to take risks and make mistakes during his effort to learn, thus an ambiance which allows children to be more independent in their thought and reasoning.

Goodman & Burke (1980), believing that readers have the "right to be wrong" state that, "Readers screen the language and thoughts of another person through their own language and thought processes. They must expect to vary from the author's intensions. Reader's willingness and ability to risk such variations thus become of central importance (p. 16). The term "guessing" which is another label attached to the meaning of prediction stems from Goodman's conceptualization of reading as being a "psycholinguistic guessing game". Often the term 'hypothesis testing' is also used synonymously with that of predicting.

Smith considers that "learning and comprehension can not be separated. Comprehension is essential for learning and learning is the

basis of comprehension" (1975, p. 97). Smith sees comprehension and learning as being essentially the same. He states that, "in order to comprehend one must predict; in order to learn one must hypothesize; and both the prediction and the hypothesis come out of our theory of the world" (1975, p. 97).

Smith makes a fine distinction between prediction and hypothesis testing. He states that "predictions are based on something already part of our theory of the world - 'Do I recognize a cat or a dog over there?' - while hypotheses are tentative modifications of the theory - 'If I am right then that will be a cat over there.' Predicting and hypothesizing, striving to comprehend and striving to learn, are going on all the time. They are as natural and continuous for the child as breathing" (1975, p. 97).

Smith claims that not only scientists but all individuals in all natural learning situations learn by experimenting. In all situations experiments are performed in order to test one's hypothesis. Children test their hypotheses about the language by experimenting with the language. They, according to Smith, collect data by observing the reactions of others in order to examine whether or not their communicated thoughts have been appropriately transmitted. "We learn to read by reading, by conducting experiments as we go along. We have built up a sight vocabulary of fifty thousand words, not by someone telling us fifty thousand times what a word is, but by hypothesizing the identity of new words that we meet in print and testing that our hypotheses make sense in the context" (1975, p. 97). Smith adamantly

states that when a reader conducts experiments while he reads, he not only learns to recognize new words he ..."learns everything else to do with reading" (p. 97).

Goodman and Burke (1980) advocate within their model of reading the importance the process of prediction plays in facilitating the reader's comprehension of the printed message. Similar to Smith (1975), Goodman and Burke (1980) stress the importance of using our own language proficiency and world knowledge in order that we may formulate personal expectations concerning the selection to be read. In an unconscious manner, the reader, prior to reading, poses such queries as, "Will this story be fiction or nonfiction?", "Will the next word be a noun or a verb?" or "Will the following letter in this word be a vowel and if so will it be an "a" or an "e"?" Thus, for the most part, unaware of such queries, the reader is continually setting up his own tentative expectations as to what might subsequently occur. Goodman asserts that the instant the reader glances at the page, the process of prediction commences.

As experienced language users, we are not forced to focus on every punctuation mark, letter, or word, and in some instances, every sentence. Each and every available linguistic cue does not require the reader's attention, since we can normally very quickly ascertain whether they are significant or not.

While reading, an individual expects to find meaningful language or language that makes sense. If, however, the word, sentence or passage did not make sense, the reader may be required to cease reading for a

moment in order to reconsider the problem. He may be required to reread the material, alerting himself to additional cues until the meaning becomes more clear, or he may decide whether it is worthwhile to continue reading in order to generate more contextual information. Such re-examinations are a confirming or disconfirming of the reader's predictions says Goodman. Thus readers must continually test their predictions in order to ascertain whether or not they make sense within the constraints of the print.

Goodman also believes that the process of prediction is aided by the reader's integration of his personal storehouse of knowledge with that of the textual information. Prediction comes far more easily and rapidly to the reader whose schema for the particular passage resembles that of the author. If, however, the reader's personal opinion differs greatly from that of the author, the strategy of prediction becomes more difficult. The reader in this case must ponder as to whether he will accept, reject, or modify the author's statements so that it can be tolerated within his own framework of knowledge.

Goodman and Burke (1980) view the strategy of prediction as occurring from three different levels during reading, from the grapho-phonic, syntactic and semantic levels. The reader's intuitive knowledge of grammar facilitates his prediction of the syntactic structures within the passage and the reader's theory of his world enables him to predict the semantic structure or the author's meaning. Goodman and Burke propose that "readers select the most significant graphophonic, syntactic and semantic cues and predict what they believe

subsequent graphophonic, syntactic and semantic structures are going to be. No reader uses all of the available cues ...The weighing and significance the reader gives to the individual cues vary with the experiences and language information he or she brings to the text and depends on the reader's specific purpose." (1980, p. 6).

Within Goodman's exploration of the reading process he devised a miscue analysis which it is claimed enables an instructor to measure his students reading processes in action. According to Goodman and Burke (1972) the reader's misreading or miscue may occur whenever there is a mismatch between "the language of the reader and the language of the author" (in Cronin, 1982, p. 40). It can not be assumed that all miscues will interfere with the reader's comprehension of the print. A miscue would be considered faulty if the reader's predictions did not accurately retain the syntactic and semantic structures within the text. Predictions in this case would distort the readers comprehension. On the other hand, when the reader's predictions resulted in a miscue which does not affect the correctness of the textual syntactic and semantic structures, comprehension, still occurs. Accordingly many of the miscues made by fluent readers are still considered meaningful within the text (Cronin, 1982).

According to Fagan (1981) prediction made while reading always follows the sequence of the printed information. Fagan advocates that prediction, more than any other cognitive process, tests the flow of language. He alerts us to the fact, however, that individuals who possess a knowledge of the syntactic system of the language, but who

have little or no understanding of the semantic content, are nevertheless capable of answering questions in relation to the text. A reader, confronted with the nonsense sentence, "Jupy is a bleak", would be capable of subsequently recalling that Jupy was a bleak even though little meaning was derived from the sentence itself.

Knowledge of syntax alone would provide the reader with the information that a noun, for example, is required in order to complete the sentence. Knowledge of spelling patterns will also facilitate, at a word level, the reader's prediction of the upcoming sequence of letters. Hence, upon viewing the word "bleak" the reader may need only to focus on the initial and final letters in order to pronounce the word correctly. Thus, Fagan espouses the imperativeness of the reader's understanding of not only the syntactic but the semantic content within the passage.

Beebe and Phillips-Riggs (1980), in conjunction with the aforementioned researchers, also stress the fundamental importance of the reader's knowledge of his surrounding environment and of language in addition to his knowledge of the task at hand.

In a crystaline manner Beebe et al. delineated not only how prediction, but all of the cognitive processes work interdependently with one another to facilitate the reader's comprehension of the text. Similar to Smith (1975) and Goodman & Burke (1980), Beebe et al. proposed that initially upon confrontation with the print, the reader must select which available linguistic cues he will attend to. Specific cues are selected in conjunction with what the reader himself predicts

he will find on the page. He uses his prior knowledge in order that he may formulate associated meanings that may be generalized to the selected printed cues. Both the already existing and newly acquired information is stored within the reader's internal system of knowledge, enabling him to make further predictions about the upcoming message. Beebe et al. warned however, that if the reader possesses an inadequate amount of background knowledge predictions or hypotheses may be inappropriate. Accordingly it is propounded that it is incumbent upon instructors to ensure the student's introduction and familiarity with the story or passages topic, so that sound and logical predictions can be made.

Beebe et al. advocate that "guessing" is an important factor within the process of prediction. When a difficult word presents itself within the passage, the art of guessing needs to be encouraged. Rather than looking at the word more closely Beebe et al. suggested that the reader should think of words that begin with the initial letter of the difficult word, and that would make sense within the context of the sentence. They state that "Fear of reprimand for the incorrect "guess" can stifle a child's ability to impose his knowledge of language and the world onto his reading" (1980).

Stauffer (1969) devised the "Directed Reading-Thinking Activity" (DR-TA) on the premise that students would be more motivated to want to understand a story better if they were put into the position of setting their own purpose for reading and making their own predictions concerning what events they believe would take place. Each story or

passage within the DR-TA is cut into sections with only one visible segment dealt with and expanded upon at one time. During critical points in the story these artificial interruptions provide the opportunity for students to discuss, reflect and query their original predictions. They are given the freedom to formulate their own judgements and expectations, not only by rereading the text, but also by being encouraged to verbalize and listen to the evaluated predictions and consensus of other students. Upon comparing their predictions with their classmates, students are then responsible to either accept, reject, extend, or modify their initial speculations. From Stauffer's viewpoint learning how to predict while reading forces the student to become more thoughtful and thus more actively involved in comprehending the selection being read.

In summary, this section primarily referred to the Psycholinguistic theorists who advocated the process of prediction to be a key strategy within their model of reading comprehension. In general, a prediction is a forecast that is made about future or upcoming events, taking into account the presently known information which is relevant to the selection being read. Within the process of prediction the reader is required to bring to the story all of his relevant background knowledge in order that he may take a more interactive and expressive role during the communicative exchange. Prior knowledge is not only referred to as the reader's view of the world but also as his knowledge of the graphophonic, syntactic and semantic structures of the language, and his knowledge of the task at hand (Beebe et al., 1980 & Cronin, 1982).

According to Smith (1975) meaningfulness lessens the number of distinctive features within the print the reader needs to focus upon. Thus readers proficient in hypothesis testing and/or predicting strategies are capable of formulating numerous high quality interpretations of the textual information in a minimal amount of time.

Smith referred to prediction as the questions the reader continually asks himself while reading. Comprehension is realized when the reader locates the appropriate information with which to answer the questions. Once tentative questions or predictions are made, Goodman and Burke (1980), in addition to Stauffer (1969), state that the reader, in a sense, experiments with the printed information in order to appraise, confirm, reject, refine, or integrate the initial interpretations within his personal storehouse of knowledge. In essence good readers are continually modifying their predictions in order to keep the meaning fluent.

8. Inferring

In the past the distinction between literal comprehension, which was "reading the lines" and nonliteral comprehension, which was reading "between the lines" or "beyond the lines", was often considered to involve a higher level thought process referred to as Inferring. According to Beebe and Phillips-Riggs (1980), "Comprehension in reading involves using a set of procedures that allow the reader to select from his personal experiences and knowledge about the world, those concepts or ideas that are relevant to the text at hand. As a reader works through a passage, he often elaborates on what is implied by the author

and arrives at intended inferences" (1980, p. 5). Hence an inference is constructed on the basis of the author's statements in the passage and what the reader contributes from his personal experiences. Gerhard (1975) in an interesting manner, views inferring as a very subtle and difficult component of reading comprehension. He sees the words and phrases as being the key which opens the reader's mind to the hidden implications "between the lines".

The process of inferring is often considered to be synonymous with that of prediction. An inference, like a prediction makes use of the reader's past experiential background in addition to the information stated in the text. In the same manner that a prediction needs confirming an inference requires justifying. During prediction the reader is always in the position of confirming whether or not his "guesses" were accurate. He is continually capable of referring back to the explicitly stated message. When an inference is made however, the reader is unable to ascertain its validity due to the fact that all of the necessary information is not included within the print. Therefore, students must show how their experiential inclusions make sense and thus logically enrichen the stories content.

Both inferences and predictions commence with the information stated within the passage, but a prediction, flowing from the sequence of the information, is constrained by the explicit graphophonic, syntactic and semantic structures within the text. On the other hand, an inference as defined by McLeod (1978) is..."information that is not stated explicitly by the author but which is generated by the reader, on

the basis of, and within the constraints of the information provided by the author. Thus, the reader must go beyond the textual information by relating it to prior knowledge" (in Beebe et al. 1980). Concurring with this thesis Henry (1975) believes that an inference is in essence a voluntary inquiry for a context. As long as the reader possesses a purpose for reading, he will bring something from his personal experiences that will bear on what he is reading. It is Beebe et al.'s opinion, therefore, that inferring possesses all of the attributes of prediction, but extends further than predicting because it instantiates (Fagan, 1981) the message with the readers personal knowledge or experiences.

On occasion, however, the distinction between predicting and inferring may be so fine that the two processes appear to be identical. An example of such seems to occur within Beebe et al.'s (1980) reference to the miscue analysis of a grade two student. The student made four miscues which made sense and were relevant to both his personal experiential background and the passage he was engaged in reading. Although the textual words were misread and considered as miscues they were also considered acceptable since comprehension had occurred. From the writer's viewpoint the four predictions in this case may be considered as inferences due to the fact that the students background knowledge depicted a meaningful representation of the author's explicit statements.

According to Cronin (1982) and Malicky (1982) inferring and predicting are advocated as being "twin reading processes". Cronin

asserts that this fine line between the two processes probably stems from McLeods (1978) theory of "backward" and "forward looking inferences". According to Cronin, "backward-looking inferences are made as the reader links new information in the text with previous information from the same text" (1982, p. 73). The reader, drawing from his background knowledge, adds more depth and thus enrichens the intended meaning by connecting together the author's literal or explicit statements. These inferences also "bridge the gap" between the author's explicit statements and those implicit ideas which are considered by the author to be already understood. Accordingly, it is the task of the reader to bring to the story his past experiences in order to 'read beyond the lines'.

Cronin clarifies that, on the other hand, forward-looking inferences are constructed by using the information from the backward-looking inference in order to predict upcoming states or events. Cronin proposes, however, that while reading, some "Elaborating or embellishing may not be considered as an inference, as it is unsubstantiated by stated text material; but neither is it considered an error in comprehension or recall, as it does not contradict any of the explicit statements, being simply an embellishment of the schema introduced by the author" (1982, p. 74).

New information introduced into the passage by the reader, may interfere with comprehension if it conflicts, as opposed to embellishes, the author's intended meaning. According to Fagan, incorrect implications drawn from the text are labelled as "Erroneous" or "Faulty Inferences".

Within Fagan's "Comprehension Categories For Protocol Analysis" (1981) the process of inferencing falls within the category of "Text Experiential". Text Experiential is regarded as information which is introduced by the reader to bridge the gaps in the passage. The reader "reconstructs" the author's statements based on his past experiences.

Fagan refers to an inference as being composed of either logical reasoning or pragmatic reasoning. Logical inferences involve the comparison of ideas which can be logically proven. Mathematically a logical inference may be depicted as, if A=B=C then A=C. Fagan cites an example of a logical inference during a story recall situation.

> Text: John and Bill left for school at the same time and walked at the same rate. But Bill lives several blocks farther away from the school than John. John just reached the school on time. He hoped that Bill would still be able to play ball that evening.
>
> Protocol: (Logical): Bill was late for school.
>
> (Fagan, 1981, p. 8)

Similar to McLeod's Backward Looking Inference, Fagan states that Pragmatic Inferences occur when the reader brings to the story his personal background knowledge in order to fill the gaps left by the author as being implicitly understood. Inferences of this nature may also work in the reverse situation whereby the written communication is used to bridge together the already existing personal experiences of the reader. Fagan states that a pragmatic inference may be stated as a contradiction and still be regarded as a plausible interpretation. An

example of a pragmatic inference during a reading situation is cited by Fagan:

> Text: The mother bundled the children in their parkas, scarves and mittens. She was sure they all had a hot lunch as they left for school.
>
> Protocol: (Pragmatic): It was a cold day.
>
> (Contradiction: It was not a cold day. Perhaps the mother was mentally deranged).
>
> (1981, p. 9)

According to Phillips-Riggs' (1981) conclusion, there are ten strategies grade six students employ in order to arrive at a pragmatic inference.

I. Rebinding inferences are inferences whereby the reader makes a decision concerning the textual meaning and immediately changes his opinion of the meaning since it conflicts with the previous information and thus decides on another interpretation.

II. Questioning a Default Interpretation - In this case the writer queries his prior interpretations on the basis of newly read information.

III. Shifting of Focus - the reader focuses on related information rather than the key topic.

IV. Analyzing Alternatives - the reader contains within his mind two or more tentative choices as to possible interpretations of the data.

V. Assigning an Alternative Case - a reader cues on to an alternate interpretation when both the previous and existing information

states are confusing and does not provide a solution. Often nonproductive, this inference is held in suspension from other information as a separate possibility.

VI. Confirming an Immediate Prior Interpretation - The reader quickly reinforces a subsequent interpretation in order that it will coincide with the immediately preceding interpretation.

VII. Confirming a Non-Immediate Prior Interpretation - due to newly acquired information, the reader reverts to and confirms an earlier interpretation.

VIII. Assuming a Default Interpretation and Transforming Information - (a nonproductive or erroneous inference) The reader makes a particular assumption based on incorrect knowledge or misconstrues new information in an attempt to verify a preceding interpretation in spite of the fact that there are inconsistencies.

IX. Neglecting to Respond or Hold Information - similar to inference type #5, this inference is also nonproductive as the reader gives up or merely rephrases, without the addition of new information, the same interpretations already made.

X. Empathizing from Experience - from the reader's own experiences, he puts himself into the textual situation and thus re-experiences the situation for a second time.

The type of inferring strategies employed while reading separates the proficient from the non-proficient readers (Phillips-Riggs, 1981). Therefore ..."the type of knowledge a reader brings to the page and how he utilizes it to make specific textual connections in part explains how

literary works are appreciated on different levels" (Cronin, 1982, p. 74).

In summary, it may be stated that an inference can be viewed as the integration of both the author's and reader's personal knowledge and experience. The information from the text becomes intertwined within the reader's schema or experiential framework. It has been stated by Cronin (1982) and Malicky (1982) that the strategies of inferring and predicting may be viewed as twin processes. Beebe et al. on the other hand have attempted to explain how the two processes can differ on the basis of how inferring goes beyond predicting as it incorporates more personally the reader's world knowledge and experiences.

Two major types of inferences were discussed. Backward-looking (McLeod, 1978 & Cronin, 1982) inferences occur when the reader connects explicit statements in order to extend and enrich the textual meaning (Beebe et al. 1980). These inferences were considered as instantiations whereby the reader was able to draw implications beyond that of the text.

The second major category was Forward-looking inferences (Macleod, 1978 & Cronin, 1982) which were viewed as interpretations made using information from the backward-looking inference in order to predict future events within the story or passage.

Fagan (1981) referred to logical and pragmatic inferences. Ten strategies of pragmatic inferencing were proposed by Phillips-Riggs, each of which were elaborated upon. Reference was made to Fagan's "faulty or erroneous inferences" whereby incorrect implications drawn from the text interferred with the reader's comprehension.

Summary of the Chapter

This chapter has attempted to describe and analyze in detail the eight major cognitive processes that Fagan (1981) advocated to be involved in facilitating comprehension during reading. The writer has surveyed the literature relevant to process oriented reading instruction in order to ascertain how numerous reading researchers, in addition to Fagan, defined and interpreted the processes of:

1. attending,
2. analyzing,
3. associationg,
4. generalizing,
5. classifying,
6. synthesizing,
7. predicting/hypothesis testing, and
8. inferring.

CHAPTER FOUR

RELATIONSHIP BETWEEN THE PROCESSES OF SCIENCE AND READING

Introduction

This chapter will examine the relationship between the processes of science, and reading as dealt with in chapters two and three respectively.

Initially, the similarities and/or differences that exist between those processes which directly correspond, in name at least, in both the science and reading disciplines, will be discussed. Specifically those processes are:

1) classification,
2) prediction, and
3) inferring.

Subsequently, there will be a discussion of the possible relationship between those processes which, in name at least, are specifically related to either the discipline of science or the discipline or reading. The processes of science which may have a possible relationship to reading are:

1) observing,
2) measuring,
3) communicating,
4) controlling variables,
5) interpreting data,
5) defining operationally,
6) hypothesizing,
7) formulating models, and
8) designing experiments.

The processes of reading which may have a possible relationship to science are:

1) attending,

2) analyzing,

3) associating,

4) generalizing, and

5) synthesizing.

In the following section a brief summary of the salient or key definitions within each of the reading and science processes is provided. Each process in reading is located adjacent to a corresponding science process, so that an understanding of their similarities and differences can be quickly ascertained. Subsequently, the relationship between the process in reading and science will be more fully discussed.

READING	SCIENCE
Classification Definitions - All realms of reading can be viewed as an act of classification -Language itself is constructed in an additive or hierarchical fashion. -readers organize letters, words, sentences into classes (graphophonic, semantic or syntactic) in order to identify, interpret and predict the written message. -A concept is in essence a classification and reading is concept development. -Conceptual understanding of the printed symbol is a prerequisite to reading comprehension.	Definitions - scientists explain their environment by putting some kind of systematized order upon nature (conceptual structures). -classification is the grouping or seriating of objects, concepts or events on the basis of some observable qualities. -an element, which is the smallest unit of analysis within a defined class or set, is as versatile as an object(s), statement or idea. -as scientists become advanced in classification skills, what was once a matter of conscious deliberation, becomes automatically a part of observation. -classification depends upon critical observation.

Similarities - classification facilitates the organization and reduction of the overwhelming amount of data one must deal with in any situation that requires thought - classification makes incoming information more meaningful.
-classifications are arbitrary in nature - suiting the needs of the individual or society at large.
-classification is a means through which data is processed, rearainging, comparing and contrasting data in order that it may be interpreted or conceptualized.
Differences - the difference between classification in reading and science is the material (symbols or observed objects or events) of which the elements being classified are comprised.

Prediction Definitions - reading is a psycholinguistic guessing game and thus prediction is a key process in reading comprehension (often referred to as hypothesis testing.) -predictions forecast future events, taking into account all presently known information (prior knowledge, graphophonic, syntactic and semantic knowledge of language). - Predictions are constrained by this information. -the more instantaneous the background knowledge (nonvisual info.) becomes, the less the reader needs to focus on the print (visual info.). -predictions are defined as the questions the reader continually asks himself while reading - comprehension is the receiving of those answers.	Definitions - predictability is one of the most important characteristics of science. -predictions are based upon the scientist's possession of relevant background knowledge and accurate predictions - otherwise they are regarded merely as guesses. -predictions are made on the basis that scientists expect the universe to operate in a regular manner. -predictions are tentative in nature and are modified according to new incoming data.

Similarities - predictions are considered as being a key process in both science and reading.
-just as readers expect the language in the text to make sense, scientists expect the universe to operate in a regular manner.
-both readers and scientists check their predictions against the surrounding text or the observations made in order to ensure their accuracy.
-in both disciplines predictions are tentative in nature and can be modified according to new incoming information.
-in both disciplines the more background information the individual possesses, the more quickly and accurately the predictions can be made.
-in both disciplines predictions are constrained to the material at hand and to the relevant prior knowledge, otherwise they would be considered as guesses.
Differences - there is a greater distinction between the terms prediction and hypothesizing in science than in reading - in reading the two terms are almost synonymous.
-predictions in science are based on information that is already a specific theory, whereas testing of a hypothesis is the testing of a tentative modification of the theory.

READING	SCIENCE
Inferring Definitions - inferring is an elaboration of the author's implications. -inferring goes beyond predicting as it incorporates more of the reader's personal background experiences, rather than just the background info. relevant to the passage. -Backward Looking Inferences - reading connects explicit statements in order to enrich the textual meaning (drawing implications beyond the text) -also referred to as Pragmatic Inference. -Forward Looking Inferences - interpretations made using backward looking inferences in order to predict future events within the passage. -Logical Inference -logically proven - if A=B, B=C A=C.	Definitions - inferring (which is a data interpretive skill) is an act of going beyond the facts or given information - thus it is a suggestion of more info. than was actually observed. -observations must support the inferences made. -there must be a distinction made between inferences and actual observations. -language used to construct the inference must reflect its uncertainty -inferring was regarded in terms of classification - inferring whether or not an object has the defining properties of a class of equivalent objects.
Similarities -in both reading and science an inference is regarded as going beyond the explicit statements or the observed data. -in both disciplines it is acknowledged that predictions are made based upon the existing inference. -in both cases inferences must be supported by direct/indirect observations or the author's statements - otherwise 'faulty'/erroneous inferences occur. -the language that reflects the tentativeness of the inference is important in both fields of study. -although not referred to in reading, the relationship between inferring and classification is evident in both disciplines. Differences - There appears to be no room in science for the 'implicitness' that there is in reading. -In science there are no terms such as 'forward', 'backward' and 'pragmatic' inferences as there is are in reading.	
Attending -determines both the type and amount of external stimuli the reader receives receives through his various sensory channels. -first step a reader takes is to decode the graphic data. -perceptual process in reading involves critical observation (comprehension is a natural extension of the perceptual process). -'Bottom-up' - reader attends to each and every graphophonic detail. -'Top-down' - reader attends to only the most appropriate details. -reader adopts his attending behavior according to his purpose for reading.	Observing - utilization of all five senses - leads to the posing of questions. -most basic scientific skill essential for the development of all scientific processes, preliminary step in conceptualization of info. -expressed in qualitative or quantitative form. -scientists must distinguish between observations and inferences. -inferences, predictions, classifications, conclusions etc. all must be supported by accurate observations. -patterns of events are looked for rather than making continual single observations.
Similarities - both attending and observation are basic processes in conceptualization of the written word or scientific information. -both attending and observation receive external stimuli through the various sensory channels -there is a subjectivity involved in both observation and attending. Differences - Observation in science refers to use of all five senses, whereas attending in reading normally refers to only auditory and visual sensory channels.	

READING	SCIENCE
Measuring -(no specifically related process) -language is a logical ordering of units (letters, words).	-treating data mathematically - computing, using statistics etc. -identifying and sequencing/ordering of lengths. -ascertaining speed, force, temperature, length, area, volume, weight, etc.
Similarities - Measuring and language both involve a logical ordering of units, either numbers or symbols. -there is linearity to both measurement and language. **Differences** - mathematical computations such as numerical equations are not used by the reader.	
Communicating - 5 major components of communcation are:1) reading, 2) writing, 3) listening, 4) speaking, 5) viewing - reading is an integral part of the communication process. -communication/language cannot be separated from thinking, and therefore cannot be separated from thinking. -comprehensional processes are in essence the translating of language into thought. -language allows one to make sense out of their world.	-communication is fundamental to all human activity. -many different ways of communicating info in science (ie) graphs, charts, maps, mathematical equations, formal and informal reports, indiv./group reports. -clear, concise and comprehendable communication is essential (for other scientists and/or the public). -observations must be recorded in a brief succinct manner, with specific vocabulary. -scientific concepts require rich enough language to express them (and in turn well articulated ideas facilitate concept development). -communication is considered an 'over-arching' process required in the performance of all science processes.
Similarities - Communication is fundamental to all human activity and to any intellectual activity. -not only scientists and readers but all humans depend upon the 5 components of communication to make sense out of their worlds. **Differences** - It is unlikely for the reader, like that of a scientist, to communicate information in the form of graphs, maps and mathematical formulas and equations.	

READING	SCIENCE
Controlling Variables (no specifically related process)	-variables within an investigation are defined as factors or properties which influence the object, situation or event under study. -variables are subject to continual change. -variables need to be identified early in the investigation for it aids the decision as to what type of data should be collected. -all variables which influence an investigation must be either tested or controlled. -independent variables are altered, while the others remain constant in order to observe possible changes. Those variables that change are the dependent variables.
Similarities - In order for predictions to be made, both scientists and readers must have control over the numerous variables that they must contend with during an experiment or the reading of a passage - (graphophonic, syntactic or semantic variables). Differences - the isolation of variables is more of an extemporaneous activity in reading. -the scientist may be more consciously aware of the controlling of variables.	
Interpreting Data (no specifically related process)	-data interpretation enables a scientist to bring meaning to his observations in the form of inferences, generalizations or explanations. -distinctions should be made between observed facts and interpretation of those facts. -observed data is put into trends/patterns so that generalizations can be made. -data is more easily interpreted when it is depicted in graphic or equation form. -each individual's past history will influence their interpretation of the data.
Similarities - both scientists and readers need to continually interpret the observed or linguistic data in order to bring meaning to it. -each individual's past history will reflect how they will interpret a situation. Differences - normally scientists interpret observed data, graphs, charts, and readers interpret linguistic and semantic data.	

READING	SCIENCE
Generalizing -product of a generalization is a universal rather than a specific statement aimed at the majority or the whole. -process of generalizing involves the combining and/or extending of once separate pieces of information (letters, words, concepts) in order to ascertain a relationship of commonalities. -generalizations can be a transference of information from one environment to another. -generalizations may be tentative laws, models or concepts constantly in the position of being revised, omitted or extended upon.	-isolated data remains useless until it is fitted into some sort of generalization. -generalizations are descriptions of the relationships between dependent ad independent variables. -generalizations aid in assessing validity of initial predictions and hypotheses. -the findings within an investigation may be generalized to a new environment.

Similarities - in both fields of study - the isolated data (observed data or graphophonic cues, letter arrangements, word meanings) is useless until it is incorporated into some type of generalization.
-generalizations are referred to in both fields as tentative laws or models of a concept which can be revised and/or extended upon.
Differences - it appears that only the material being generalized differs in science and reading.

Hypothesizing -often hypothesis testing is used synonymously with predicting -hypothesis testing involves the reader continually asking himself questions, therefore setting up his own expectations as to what might occur in the passage. -distinction between hypothesis testing and prediction is that predictions are based on something already part of our theory of the world, whereas hypothesis testing is a tentative modification of that theory.	-hypothesizing is the proposing of possible but tentative explanations based on one or more observations. -hypotheses and predictions are closely related but a hypothesis must direct an observation or investigation in a manner than can be proved or disapproved, whereas a prediction does not have to direct an investigation (hypoth. are selecting devices). -hypotheses are guesses about the relationships between variables. -if a hypothesis is clearly stated most of the planning for data collection is already done. -hypotheses are considered as building blocks for theory construction, or a theory may be a fairly well confirmed hypothesis.

Similarities - in both disciplines hypotheses are tentative statements of a theory.
-in science, experiments are performed to test the hypothesis(es), and in reading the reader continually tests his hypothesis of the content in order to keep the meaning fluent within the proper context of the passage.
-in both disciplines hypotheses are 'selecting devices' which set the stage for data collection, or to direct the readers attention to the upcoming printed message.
Differences - in science there is a definite distinction between hypothesizing and predicting, whereas in reading they are often considered synonymous.
-in science a hypothesis is concisely stated, whereas in reading it is more of an unconscious action which is rarely verbalized or recorded.

READING	SCIENCE
Formulating Models (no specifically related process)	-scientific models involve physical, mental or theoretical representations which depict characteristics which cannot be explicitly observed. -attempts to be an exact copy of a physical structure - enabling scientists to think in concrete terms. -it is important that the model fits the data as opposed to forcing the data to fit the model.

Similarities - The printed message may be somewhat like a model as it is a graphic representation of the author's ideas.
-Dramatizations of the author's ideas may facilitate in concrete terms, the reader's comprehension of the text.
Differences - Readers do not make physical copies of an hypothesis or theoretical structure as a scientist does when he tries to visualize an idea in concrete terms.

Designing Experiments -reading researchers state that individuals learn by naturally experimenting with the surrounding environment. -readers hypothesize the meaning of words they meet in the print and test that their hypotheses make sense in the context of the passage. -experiments are performed in order to solve problems - in reading the problem to be solved often occurs within the story's plot, the lead up to the climax and to the final solution to the question or problem.	-it is the synthesis of all of the available info. in order to test the hypothesis. -it is the planning of an investigation in order to obtain a solution, a conclusion or to ascertain an unknown law. -conclusions can be extended to a general population if the variables within the experiment are well controlled. -no one correct 'scientific method' - numerous methods for solving different problems at different times (often trial & error situations). -experimenting is an open-ended affair - science is always an unfinished business.

Similarities - experimenting is a natural learning method regardless of the subject area.
-both scientists and readers are continually experimenting with the observed or linguistic data in order to test their hypotheses.
-some researchers have applied the scientific method to reading.
Differences - in science an experiment is a systematic and controlled procedure in comparison to the more extemporaneous manner a reader experiments with the print. Readers do not as strictly deal with the relationship between variables as scientists must do within their investigations.

READING	SCIENCE
Analyzing -analysis is the discrimination, organization and abstraction from the visual information supplied by the print. -it is the act of separating information for the purpose of ascertaining both the component parts and their relation to one another. -analysis and synthesis are said to be the two major elements within concept development. -'Unit of Analysis' a reader selects to use ('Bottom-up or 'Top-Down' Theory) depends upon his purpose for reading.	-analysis is inherent in 'data processing'. -through analysis one separates/dissects the data into its constituent parts (breaking down the components according to their various relationships). -scientists categorize, graph, chart and use numerical computations in order to facilitate analysis.
Similarites - in both disciplines analysis appears to be the breaking down or dissecting of observed or linguistic data for the purpose of ascertaining their components parts and relating to each other. Differences - in science the word analysis appears to be an umbrella term for all data processing skills such as classification, seriation, and graphing, whereas in reading it is a unique process separate from classification and seriation. -in science there are no specific 'units of analysis' as depicted in the 'bottom up'/'top down' theories in reading.	
Associating -associating is the linking, joining or combining of equivalent information in order to ascertain a newly observed relationship. -readers need to know sound/symbol and word/meaning associations in order to comprehend the text. -there are four types of associations discussed in reading: sign, assigned,	ascertain a relationship (e.g. An individual's IQ in relation to his academic performance may be tested). -many statistical procedures are used in research in order to determine the relationship between variables.
Similarities - The Behaviorist Learning Theory stems from associationism. -in science associations of observed data help to ascertain relationships between the masses of data and/or variables that exist within an experiment. In reading, readers require the understanding of sound/symbol and word/meaning associations. -in all fields of study association is the combining of information in order to see an equivalent relationship. Differences - In science, the process of association is used to determine the relationships between variables through statitical methods which do not occur in reading.	

READING	SCIENCE
Synthesizing -synthesis is regarded as a major focus, a central theme, a main idea, a generalized summary or a structure of relations. -both analysis and classification dissect information into its constituent parts whereas synthesis summarizes various classes of information and reconstructs it in a manner that was previously nonexistent. -synthesis is the inventing of a structure - which is the relating of rational discoveries (classes). Thus relating newly made classes until a structure concept is attained. -A reader performs a sentence, cross sentence and passage level synthesis.	-the coalescing of information in order to view the overall trend or effect that is occurring.

Similarites - in both disciplines the act of combining the analyzed information is a synthesis. Both the reader and the scientist are looking at the already classified information in order to see a trend, theme or prevailent cycle.

Differences - synthesis is not a specifically stated process in science as it is in reading.

-there are no terms such as sentence, cross sentence and passage levels synthesis in science as there is in reading.

Relationship Between Processes in Reading and Science

1. Classification - Similarities

The process of classification involves the reduction of experience into a more manageable form, whether it be masses of scientific data or masses of symbols within the text. The reader is as dependent upon classifying the symbolic data as the scientist is dependent upon using classification in order to organize and reduce the overwhelming amount of incoming data. Classification makes information more meaningful whether it is information a reader receives from the text or information a scientist receives from a series of observations.

Just as a scientist learns to improve his classificatory skills so that he can merely observe what he once had to take time to classify, a reader may also classify every detail when first learning to read. For example, a young reader learning to decode the print may classify "a" as belonging to a group of letters - a group known as vowels and as a group known as small as opposed to capital letters. As a reader matures all of these conscious deliberations can, like that of a scientist, be merely observed.

With respect to comprehension, a mature reader can more quickly discriminate the "main idea" of a paragraph or passage from the relative supporting details as he can classify words or thoughts into categories thereby generalizing meanings that include or exclude common characteristics. Seriation, which is the ordering of objects or events, can also be closely related to the sequencing of story events known as story grammars.

Differences

The major difference between classifications in reading and in science concerns the material of which the elements being classified are comprised. In reading the elements may consist of letters, words, sentences and passages whereas in science elements may consist of observed objects, events or ideas. Within reading the process of classification is implicit, whereas in science it is usually an explicit act.

Summary

Classification is an intellectual operation which is fundamental in the organization and simplification of information during any activity which requires an individual to process data. Classification operates in a very similar manner in both reading and science.

2. Prediction

Similarities

Prediction is considered a key process in both science and reading. Readers expect the language in the text to make sense and scientists expect the universe to operate in a regular manner. They both establish their predictions on the basis of ordered data. A reader continually checks his predictions against that of the printed message in order to keep the meaning he has attained congruent with that of the surrounding text. In the same sense the scientist must continually check the accuracy of his predictions against his observations in order to ensure that his thinking is consistent with the data. In both cases the reader and the scientist forecast what the future observation will be.

In both disciplines the reader and scientist are constrained by the material at hand for, predictions not based on observations or the authors statements are referred to as guesses. With respect to both reading and science, predictions are tentative in nature and in light of new information predictions are either accepted, rejected or modified. If the scientist or the reader finds that the predictions made were faulty or unacceptable, they would have to go back and reread the passage or reexamine the existing data in order to help validate the investigation or author's statements.

Within the reading act the more nonvisual information or prior knowledge the reader has within his reach the more quickly the predictions can be made. In science predictions are also more accurately and quickly made when the scientist possesses a sufficient amount of relevant knowledge concerning the event or situation.

Differences

There appears to be much more of a distinction made between prediction and hypothesis making in science than there is in reading. In reading the two terms of predicting and hypothesis testing are frequently viewed as being synonymous. Predictions in science are based on information already part of our theory of the world, whereas the testing of an hypothesis is the testing of a tentative modification of the theory. Prediction in reading, like that of hypothesis making in science, is the asking of questions that set the search for the answers (comprehension in reading and solutions/conclusions in science) in motion.

Predictions in reading do not require precise measurements, for example the production of graphs, as they do in science.

Summary

It appears that the actual act of predicting, whether it be predictions made concerning the results of a scientific investigation or the upcoming events in a story are processes which are very similar. In each discipline a prediction is dependent upon a situation that contains a certain amount of regularity and an individual who posseses a sufficient amount of relevant background knowledge. A prediction in science, however, is a very separate process from that of hypothesizing, whereas in reading, hypothesis testing is often considered the same as prediction.

3. Inferring

Similarities

In both science and reading an inference is defined as 'going beyond' the given information. In science an inference goes beyond that which was actually observed and in reading a reader goes beyond the text within what is termed as a 'backward looking inference' in order to interpret the meaning. The author's explicit statements in reading may be compared to the observed data in science. Although the term 'forward-looking' inference in reading is not employed in science its definition, which states that predictions are made based upon the existing inferences (Funk et al. 1979), is acknowledged in both fields.

Inferences in both science and reading must be supported by either direct or indirect observations or by the author's statements. Faulty

inferences in science often occur when the scientist has made careless or erroneous observations. In reading, faulty inferences are those that do not pertain to the author's explicit statements or what the author expected the reader should implicitly understand. In either case a faulty inference will interfere with the problem's solution or comprehension of the text; thus in both fields of study, vigilance must be exercised, for no more should be inferred than can be justified.

In both science and reading an inference is frequently an implicit act, carried out without the observer being conscious of the action itself. In both fields the inferences may not be made from specific explicit statements or direct observations as in the case of predictions.

In both reading and science several inferences can be made from a single set of observations or from only one of the author's statements. The language that reflects the tentativeness of the inference is important in both science and reading. In both disciplines the logical inference which relates to the transitive property A=B B=C A=C was earlier referred to. Although researchers have not examined the relationship between inferring and classification in reading as has been done in science, a reader would also need to make an inference, for example, that the main character in the story which is a duck, belongs to the class of Birds rather than the class of Fish.

Differences

In science there is a great distinction made between an observation and the inferences made regarding the observation. In reading, however,

the distinction between the observed word and the inferences made about the word need not necessarily be specified. The printed word "house" for example may be inferred by the reader as being "home", which is an acceptable translation as within the story there is no loss of comprehension.

Although logical inferences appear in both reading and science, there are no terms in science such as forward and backward inferences and no strategies used in order to arrive at a pragmatic inference.

Summary

Although some of the terminology is different between the two disciplines it appears that there is a great deal of similarity between the process of inferring in science and the process of inferring in reading. In both cases the individual goes 'beyond' the given information by utilizing their personal background knowledge in order to make richer interpretations. In both cases it appears as though inferring is an implicit act carried out in an unconscious manner.

4. Attending and Observation

Similarities

> "...As the child looks, listens, sees, smells, tastes, he becomes an active participant rather than a passive observer. From his experiences, he evolves a frame which will influence the way he expresses himself"
>
> (Cannon & Ladd, 1974)

Although observing is not considered a reading process it is a fundamental act which greatly faciliates the reader's ability to communicate, not only with the written passage, but as an author himself with his own audience.

Observation is considered to be the most basic skill in science, and the initial step taken within an investigation. Similarly, attending in reading is considered as the first step a reader takes in order to decode the graphic information. Both observation and attending are receptive modes of acquiring data and both may lead to the posing of questions that need to be answered.

Observation and attending are both defined as processes in which external stimuli are received through the various sensory channels. It is as important for the beginning scientist or the scientist involved in a totally new area of research, as it is for the beginning reader or the mature reader involved in reading new and difficult material, to have a critical eye that is capable of discriminating between the finer visual details.

In the same manner that scientists learn to look for patterns rather than making continual single observations, a mature reader does not have to attend to each and every graphophonic, syntactic or semantic cue because larger more meaningful patterns or chunks of information are focused upon.

Observation and attending, however, should not always be viewed in such a mechanistic manner. Scientists and readers are human, bringing with them their own histories thus colouring their observations. Therefore, within a scientific investigation when data is being observed or when a reader is attending to the details of the print an element of subjectivity is inevitably involved.

Differences

Observation in science involves the use of all five senses, whereas attending predominantly makes use of only the auditory and visual sensory channels.

In most cases the validity of a scientific investigation is dependent upon how critically the data has been observed. Each detail must be accounted for. Perhaps today this concept is the opposite in reading. As aforementioned, a mature reader continually predicts the upcoming information within the text. A reader who is comprehending the story may not need to critically attend to every detail within the print. Thus for example, the reader may attend to the letter "h" in the word "house" but reads the word "home" instead. No meaning is lost even though the lack of attention has caused the reader to misread a word.

Summary

There are obvious differences between observing and attending that have been discussed but there also appears to be a fair number of similarities which exist between these processes in the scientific and reading domains.

5. Measurement

Similarities

There is indeed a similarity between the process of measurement in science and the mathematical nature of our language. Mathematics, which is the science of numbers, is a purely logical activity. Mathematics is the basis of science and, accordingly, without mathematics there would be no science.

Linear thought is considered to be the simplest form of mathematics. It is the first degree in any number of variables and involves only a single dimension. Linearity is the basis and thus a stepping stone to the more complex realm of mathematics referred to as the higher order.

Measurement and language can be related from the point of view that measurement is a logical ordering of units (numbers) and that language is also a logical ordering of units (letters, words). There is a linear structure to the printed sentence and it may be related to a simple linear measurement in mathematics. As soon as a descriptive phrase, adverbial phrase or subjunctive is inserted within the sentence, the linearity of the thought is altered therefore making the sentence more complex, or in mathematical terms the thought or sentence is transformed into a higher order. For example, thinking and language are very closely related. In many respects our thinking is influenced by our language. A thought which may be easily expressed in one language may be difficult to impossible to express in the language of another culture.

Differences

A reader does not make use of calibrated instruments, does not measure the change of an object over time or calculate numerical equations when he is confronted with the print. Accordingly, within the field of reading, measurement has not been included as a comprehension process.

Summary

It may be said that there is some similiarity between the process of measurement in science and in reading. The process of measurement has not been included within the field of reading because mathematical equations and the use, for example, of calibrated instruments are not utilized the reader to make sense of the written word. Linearity which is the basis of measurement, also appears to be a basis of language. In both cases there is a logical ordering of units.

6. Communicating

Similarities

Communication is a process which is fundamental to all human activity and thus is equally important to the scientist and the reader. Not only the scientist and the reader but all individuals depend upon the five components of communication (listening, speaking, reading, writing and viewing) to make sense out of their worlds.

Differences

It is not as likely for the author to communicate information in the form of graphs, charts, maps and mathematical equations as a scientist would however, pictures are often used in stories to aid the communication of ideas.

Summary

It may be considered that communication is an 'overarching' process required in the performance and exchange of all thinking activities.

7. Controlling Variables

Similarities

In order for both the scientist and the reader to make predictions

they must have control over the numerous variables that must be contended with during an investigation or the reading of a passage. In science the researcher must initially identify the variables which will influence the findings in the study. In a similar manner the reader must continually be aware of not only the graphophonic but the semantic variables which will influence both the pronunciation and meanings of words in a sentence. The critical reader is constantly isolating the author's numerous statements in order to ascertain whether or not they justifiably influence the passages outcome or conclusion.

Differences

Although the controlling of variables is not included as a reading comprehension process, the controlling of numerous graphophonic or semantic variables is often extemporaneously achieved. Scientists are more consciously aware of the act of identifying variables as when controlling variables, scientists physically record variations in the dependent measures.

Summary

Although the process of controlling variables is a very important part of a scientific investigation it is also a process which is used not only by readers, but all persons when solving problems in their daily lives. Accordingly, the writer considers that there is definitely some similarity between the process in science and in reading.

8. Data Interpretation

Similarities

Although there is no specific process labelled as "data

interpretation" in reading, there is in science. A reader is continually interpreting data when he translates the written language into thought. Both the scientist and the reader are bringing meaning to their personal situation - either to the observed data or the graphic symbols. Scientists and mature readers acquire the skills of quickly sifting through the large masses of data, selecting only the most relevant information or in the case of reading only the high potency words or "chunks" of information.

Some research suggests that interpretations are the selection of appropriate data which support inferences, generalizations and explanations. It should be noted however, that each individual's past history should be recognized or taken into consideration when data is being interpreted. Every individual's experiences are different and thus one scientist's interpretation of the appropriate data which support inferences, explanations may be slightly different from another scientist's interpretation.

The same situation holds true in reading. No two people will comprehend the printed message in the same way because no two readers will bring the same experiences to the story.

Differences

A scientist interprets the observed data, patterns or changes in data, graphs, charts and maps. A reader may be required to interpret graphs, charts or maps, but most often the interpretations are limited to the linguistic and semantic data.

Summary

The study of hermeneutics (principals of interpretation) covers a very broad field of study and cannot be dealt with in full within this study. It appears to the writer that the act of interpreting is very similar in both fields but that the material being interpreted generally differs between science and reading. Both scientists and readers need to continually interpret their observed or linguistic data in order to bring meaning to it.

9. Generalizing

Similarities

Although generalizing was not included as an individual process within the list of SAPA process (p. 10, 11) its important role within the interpretation of data should not be ignored. Scientists put observed data into patterns, trends or averages in order that relationships between the data can be more easily recognized. In reading, the reader also combines isolated pieces of information (graphophonic cues, letter arrangements or word meanings) in order to make generalizations (ie., small patterns) concerning their common relationships. Thus the recognition of word or spelling patterns within the print is the making of a generalization. In both fields of study, generalizations, like classifications, help to reduce repeated information and thus the need for constant new learning is diminished. The generalizing or transferring of information from one situation to another is a fundamental learning tool for all individuals. In both science and reading generalizations are referred to as tentative laws or models which are continually being revised and/or extended upon.

Differences

Observed or numerical data is generalized into patterns or trends in science, whereas in reading letters or word meanings are generalized into patterns or similar arrangements. Thus only the material being generalized, differs within the two areas of study.

Summary

The writer believes that within the areas of science and reading the process of generalizing is very similar; only the material being generalized appears to differ. The process of generalizing or the transferring of information from one environment to another is a very important and basic learning tool required in all thinking situations.

10. Defining Operationally

Summary

Although there is no specifically related process of defining operationally in reading, as there is in science, reading skills, such as dictionary skills (selecting appropriate word meanings), word recognition skills (understanding word meaning through the use of context clues), and learning how to define specific situations, would facilitate the scientist's ability to create brief and concise definitions which would accurately explain the operation of an object or event. In essence, it is considered by the writer that scientists should have certain reading skills. It appears therefore that there is some relationship between defining operationally in science and reading.

11. Hypothesizing

Similarities

In reading and science hypotheses are possible tentative statements

of a theory. In science, experiments are performed in order to test one's hypothesis. In reading, the term "hypothesis testing" refers to the reader who continually tests his hypothesis or predictions of the written content in order to keep the meaning fluent within the context of the passage. Thus in both fields the hypothesis is tested and immediately or eventually verified. Both the scientist and the reader take into account all of the relevant data before making the hypothesis. In both disciplines hypotheses may be regarding as "selecting devices" which set the stage for data collection or direct the reader's attention towards the upcoming printed message.

Differences

In science there is a definite distinction between the making of hypotheses and predictions, whereas in reading the two terms are normally considered as being synonymous. In science causal relationships using hypothetics - deductive reasoning strategies are used. Thus hypotheses about possible relations between variables are made, an investigation is developed, and observations are made which determine whether or not the hypothesis were valid. In reading, hypothesis making is more of a continual unconscious action which is rarely verbalized or recorded.

Summary

Although the process of hypothesizing is somewhat similar in both fields of study, a reader's hypotheses are not usually verbalized, and are not only more predictive but less formalized and intuitive in nature than a scientific hypothesis. Scientist's hypotheses involve more

formal objective and explicit statements which provide clear implications for the testing of stated relationships between variables.

12. Formulating Models

Summary

Although there is no process in reading that relates specifically to the process of formulating models in science, there does appear to be some similarity within the two fields.

Readers do not usually make physical copies of a hypothesis or theoretical structure as a scientist does when he wants to visualize an idea in concrete terms. In a sense, the printed message acts somewhat like a model in that it is a graphic representation of the writer's ideas. Another comparison which possibly be made is that the dramatization of the author's ideas may facilitate, in more concrete terms, the reader's comprehension of the text. Perhaps the printed word may be viewed as an abstract model of thought or an abstract model of the world.

12. Experimenting

Similarities

Experimenting is a natural learning method regardless of the subject area in which the problem lies. Both scientists and readers are continually experimenting with the observed or linguistic data in order to test their hypotheses and/or to find an answer or solution to their problem.

There is no one scientific method which all scientists follow as if it were a magical recipe. There are as many different types of

scientific methods as there are investigations. For the purpose of science instruction, however, a specified scientific method has emerged. This form of linear thinking or so called "scientific method" of seeing the problem, defining it, stating the hypothesis, testing, and concluding; can be applied to reading. In reading the form may be to set a purpose, define the purpose while reading, and state the hypothesis, judge and conclude. The conclusions to either the experiment or story can be generalized to new situations and thus new problems are identified for experimentation.

Differences

As already stated within the section on hypothesizing a scientific experiment is a far more systematic and controlled procedure than the more extemporaneous manner in which a reader goes about experimenting with the printed symbols. Readers need not deal so strictly with the routine of specifying the relationship between variables as scientists often have to do within their experiments.

Summary

In general experimenting is a very creative process that can be applied to most circumstances in which the act of learning is taking place. Specifically however, a scientific experiment tends to be a more formal and objective attempt to test a specific hypothesis. Both readers and scientists state or have a question in mind, construct hypotheses and in their own specific way carry out experimental procedures. Therefore it appears as though there is some similarity between the two disciplines.

14. Analyzing

Similarities

In both science and reading the process of analysis involves the classification or grouping of information (observed or linguistic data) for the purpose of establishing relationships between or among the categories.

Differences

In science the word analysis appears to be an umbrella term for all data processing skills such as classification, seriation, numerical computations, and graphing, whereas in reading analysis is a separate process unique from classification and seriation. In science a careful analysis of the data is maintained in order that all of the important details have been accounted for. In reading the converse is often true because the mature reader frequently bypasses much of the detailed linguistic, syntactic or semantic information. In science there are no "units of analysis" as depicted in the "bottom up" or "top down" theories in reading.

Summary

In general terms the process of analysis can be applied to the dissection or decomposition of any information under study, regardless of the subject area, for the purpose of examining its component parts and their relationships to one another. Generally, analysis is regarded as reducing the whole to its integral parts, but such a concept of reductionism can often overlook the fact that the sum of the parts may not equal the whole. There does appear however to be some different

meanings attached to the term analysis which are only specifically related to science or reading. Therefore it appears as though there is only some similarity between analysis in science and analysis in reading.

15. Association

Similarities

The behaviorist's philosophy of human development stemmed in part from associationism which suggests that learning evolved from a series of small additive increments which gradually accumulated to form a repertoire of acts. Association in science may be regarded as the joining of two or more components of observed data in order to see a connection or relationship. Much of the basis of scientific research is aimed at the discovery of the relationship between variables. Readers require the understanding of sound/symbol or word/meaning associations. The process of association in both disciplines as in all fields of study is the combining of information in order to ascertain an equivalent relationship.

Differences

Although there is no specific process in science that is labelled association as there is in reading, it is the basis of the "systems theory". Scientists are always seeking relationships in order to understand "systems". Such types of associating as sign, assigned or attributing are related specifically to reading and language development.

Summary

The act of making associations is a fundamental basis of thinking. All individuals, whether or not they are scientists or readers, seek relationships between separate pieces of information in order to simplify their learning. Although there are no terms of attributing, sign and assigned association in science, the process is in itself very similar to both fields of study.

16. Synthesizing

Similarities

In both disciplines the act of combining the analyzed information is a synthesis. In either case the reader or scientist is looking at the already classified groups of information in order to ascertain an overall trend, pattern, theme or main idea. Both analysis and classification in reading and science dissect and break down information into its constituent parts, whereas synthesis summarizes various classes of information and reconstructs it in a manner that was previously implicit or nonexistent.

Differences

The act of synthesizing is not a specifically stated process in science as it is in reading. Such reading terms as sentence, cross and passage level synthesis are not related to a process the scientist employs during an investigation.

Summary

The general act of synthesizing (the putting together of already analyzed and classified information) appears to be a very similar

process in both fields of study and in both disciplines a synthesis yields a general pattern or a look at the 'whole'. In the same manner that a designer creates a new garment, or an architect creates a new building design, the process of synthesis facilitates the scientist to create a model that explains some aspect of nature.

Chapter Summary

This chapter focused on the investigation of the relationship between the scientific processes and reading processes as dealt with in chapters two and three respectively. A chart within chapter four was formulated which depicted a summary of definitions for each of the processes in relation to the science and reading domains. Subsequently, a brief discussion outlined the similarities and the differences which were considered to exist between the processes of reading and the processes of science. Following this discussion a brief summary of the type of overall relationship considered to exist between the processes from each discipline was stated.

CHAPTER FIVE

SUMMARY

Introduction

This study was concerned with ascertaining relationships that exist between the processes employed during a scientific inquiry and the reading processes involved in facilitating comprehension of the written language.

The following questions were examined:

1. What are the processes in science?
2. What are the processes in reading?
3. What is the relationship between the processes in science and the processes in reading?

Within this study there was a survey of the literature relevant to the Process Orientation in both the areas of science and reading. In Chapter One a discussion of the process orientation in general was made. In addition, a brief introduction of the process approach with specific regards to science and reading was included. Within Chapter Two, there was a description and a detailed analysis of the processes specified for the instruction of science in the 1983 Alberta Education Elementary Science Curriculum Guide. These processes were listed as:

1. observing,
2. classifying/Serial Ordering,
3. measuring,
4. communicating,
5. inferring,
6. predicting,
7. controlling variables,
8. interpreting data,
9. defining operationally,
10. hypothesizing,
11. formulating models, and
12. designing experiments.

Chapter Three focused on the description and detailed analysis of the processes advocated to facilitate language comprehension espoused by a number of process oriented reading theorists. These processes were listed as:

1. attending,
2. analyzing,
3. associating,
4. generalizing,
5. classifying/sequencing,
6. synthesizing,
7. predicting/hypothesis testing, and
8. inferring.

Within Chapter Four the processes from both disciplines were classified into categories. Those processes of:

1. classification,
2. predicting, and
3. inferring,

which directly correspond in name at least to both the science and reading disciplines were initially discussed.

Secondly, the science and reading processes of:

1. Observing/Attending,
2. Measuring,
3. Communicating,
4. Controlling Variables,
5. Interpreting Data/Generalizing,
6. Defining Operationally,
7. Hypothesizing,
8. Formulating Models,
9. Designing Experiments,

10. Analyzing,
11. Associating, and
12. Synthesizing.

were discussed in terms of their possible relationship to each other.

Chapter Four contained a synthesis of the canvassed literature in order that a comparison could be made between the similarities and differences that existed between the processes in the scientific and reading content areas. Within this chapter there was also an attempt to delineate those scientific and reading processes which possess a common functional foundation and those which do not.

Summary of the Findings

Upon examining the similarities and differences between the processes employed during scientific inquiry and the processes which are said to facilitate reading comprehension, it was found that the range of processes from each discipline varied from being very similar to possessing only a fair degree of similarity.

Classification was involved in a very similar or identical manner in both reading and science. It is an intellectual operation which is fundamental to organization and thus to the simplification of any type of information being learned.

Predictions made concerning the results of a scientific investigation, or the upcoming events in a story, are processes which are very similar to one another. Inferences made in reading and in science also appear to be very similar in nature. In both cases, in a somewhat implicit manner, the individual goes "beyond" the given

information by utilizing their personal background knowledge in order to more richly make interpretations.

Communicating was regarded as an "overarching" process required in not only science and reading but in all thinking activities.

Data Interpretation is a very similar process in both fields as well. Both scientists and readers need to continually interpret their observed or linguistic data in order to bring meaning to it. Generalizing is also very similar; only the material being generalized appears to differ. The generalization or transference of information from one environment to another is a basic learning tool required in all areas of intellectual pursuit.

The making of associations is also a fundamental thinking process. All individuals look for relationships between once separate pieces of information in order that their learning can be more simplified. Synthesizing is also a very similar process in both science and reading. The meshing together of already analyzed and classified information into a general pattern or "whole" is a useful process for all individuals who endeavor to create a new object, concept or idea.

The eight processes mentioned above have been considered by the writer to possess a great deal of similarity in both science and reading. The following eight processes appear to possess only some similarity in both fields of study.

Measurement appears to have some similarity in both science and reading. Linearity which is the basis of mesaurement seems also to be a basis of the English Language. In both cases there is a logical

ordering of units. There is also some similarity between the controlling of variables in both disciplines. Many people rely upon such a process when solving problems within their daily lives. When solving problems, more conclusive results are achieved when the variables are carefully identified and controlled. Defining Operationally also contains some similarity in both science and reading. Certain reading skills would facilitate the scientist's ability to create brief and concise definitions which would accurately explain the operation of an object or event.

Although hypothesizing sets the stage for the collection of observed or linguistic dat, there is only some similarity that exists between science and reading. This is because a reader's hypotheses may not be verbalized, may be predictive and more extemporaneous in nature than a scientific hypothesis.

Although formulating models is not a process in reading, as it is in science, there is some similarity that exists since the printed message may act somewhat like a model in that it is a graphic representation of the writer's ideas.

Analysis was was considered as the dissection of information, regardless of the subject area, for the purpose of examining its component parts and their relationships to one another. There is only some similarity in both fields with regards to analyses as in reading the units of analysis is an integral aspect of this process whereas in science this does not occur.

Experimenting is a creative process that can be applied to most circumstances in which the act of learning is taking place. Experimenting possesses some similarity in both disciplines since readers and scientists state or have a question in mind, construct hypotheses, and in their own specific way carry out experimental procedures. Experimentation in reading is far more extemporaneous in nature than it is in science.

Although there are obvious differences that exist between observing and attending, there is some degree of similarity that exists between these processes in both science and reading. Both processes receive external stimuli through the various sensory channels and both are considered to be the most basic and initial step taken within an investigation or the comprehension of the printed message.

Thus it appears that within all cases the sixteen processes which were compared within science and reading manifested evidence of at least some similarity or commonality.

Implications for Education

This study has implications for education through:

1) furthering the teacher's instructional understanding of the Inquiry or Process Approach in the fields of reading and science education;
2) contributing to the body of knowledge concerning the information or cognitive processing capabilities of children in the elementary grades;
3) enhancing the classroom teacher's understanding of the formulation of questions and the subsequent choice of teaching strategies best

suited to the child's information processing abilities; for example, if the teacher realizes that "hypothesis testing" is an important reading strategy they may ask questions which would facilitate the students "hypothesis testing" ability, thereby, increasing their comprehension;

4) providing educators with a more indepth understanding of the numerous definitions of each of the individual processes of science and the individual processes for reading;

5) providing information as to the relationships between the information processes taught in the science and reading content areas;

6) outlining a commonality of terms that may be employed during the instruction of processes in both the science and reading programs; and

7) providing insights concerning the writer's hypothesis that information processes are one vehicle by which educators can more effectively integrate the Language Arts, with not only the sciences, but with perhaps instruction in all subject areas across the curriculum.

Implications for Further Research

The results of this study may have some significance in furthering the research into reading comprehension instruction through:

1) attempting to reanalyze whether or not the processes, by their varied definitional structures, can be founded upon the same learning criteria;

2) facilitating the development of an empirical testing format which could analyze whether the intellectual foundation of the processes are definitionally and functionally identical, very similar or dissimilar;

3) utilizing the proper testing methodology in order that the question of transference of learning processes between reading and science may be more fully answered;

4) indicating the feasibility or the impracticality, of completely or partially integrating the instruction of reading and science processes;

5) indicating whether or not processes such as those defined in reading and science exist in other subject areas, such as math, art and social studies; and

6) ascertaining any possible relationships that might exist between the domains of math, art and social studies.

Summary

This study ascertained whether there were any relationships that existed between the scientific processes employed during a scientific inquiry and the reading processes involved in facilitating comprehension of the written language.

The findings from the study indicated that in many circumstances the processes within both subject areas were very similar in nature, whereas in some cases only a small degree of similarity or commonality existed. However, there was some degree of commonality that existed between all of the processes in science and the processes in reading.

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Appendix A

"An Inventory of Processes in Scientific Inquiry" is as follows:

I. Initiation
1. Identifying and formulating a problem
(a) speculating about a phenomenon
(b) identifying variables
(c) noting and making assumptions
(d) delimiting the problem
2. Seeking relevant background information
(a) recalling relevant knowledge and experiences
(b) doing literature research
(c) consulting people
3. Predicting
4. Hypothesizing
5. Design for collection of data through field work and/or experimentation
(a) defining the independent and control variables in operational terms
(b) defining the procedure and sequencing the steps
(c) identifying needed equipment, materials and techniques
(d) indicating safety precautions
(e) devising the method for recording data

II. Collection of Data
6. Procedure
(a) collecting, constructing, and setting up the apparatus or equipment
(b) doing field work and/or performing the experiment
(c) identifying the limitations of the design (as a result of failures, blind alleys, etc.) and modifying the procedure (often by trail-and-error).
(d) repeating the experiment (for reproductibility, to overcome limitations of initial design, etc.)
(e) recording data (describing, tabulating, diagramming, photographing, etc.)
7. Observing and observations
(a) obtaining qualitative data (using senses, etc.)
(b) obtaining semi-quantitative and quantitative data (measuring, reading scales, calibrating, counting objects, or events, estimating, approximating, etc.)
(c) gathering specimens
(d) obtaining graphical data (charts, photographs, films, etc.)
(e) noting unexpected or accidental occurrences (serendipity)
(f) noting the precision and accuracy of data
(g) judging the reliability and validity of data

III. Processing of Data
8. Organizing the data
(a) ordering to identify regularities
(b) classifying
(c) comparing
9. Representing the data graphically
(a) drawing graphs, charts, maps, diagrams, etc.
(b) interpolating, extrapolating, etc.
10. Treating the data mathematically
(a) computing (calculating)
(b) using statistics
(c) determining the uncertainty in the results

IV. Conceptualization of Data
11. Interpreting the data
(a) suggesting an explanation for a set of data
(b) deriving an inference or generalization from a set of data
(c) assessing validity of initial assumptions, predictions, and hypotheses
12. Formulating operational definitions
(a) verbal
(b) mathematical
13. Expressing data in the form of a mathematical relationship
14. Incorporating the new discovery into the existing theory (developing a "mental model")

V. Openendedness
15. Seeking further evidence to
(a) increase the level of confidence in the explanation or generalization
(b) test the range of applicability of the explanation or generalization
16. Identifying new problems for investigation because of
(a) the need to study the effect of a new variable
(b) anomalous or unexpected observations
(c) incompleteness ("gaps") and inconsistencies in the theory
17. Applying the discovered knowledge

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